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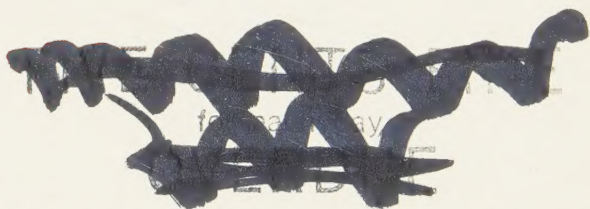


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Holder, W.

Treatise of the natural
grounds and principals of
harmony
(Broude)



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MONUMENTS OF MUSIC AND MUSIC LITERATURE

IN

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Second Series—Music Literature

XXXII

TREATISE
OF
HARMONY

WILLIAM HOLDER, 1616-1698.

TREATISE
OF THE
NATURAL GROUNDS AND PRINCIPALS
OF
HARMONY

A Facsimile of the 1694 London Edition

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A
TREATISE
OF THE
Natural Grounds,
AND
PRINCIPLES
OF
HARMONY.

By *WILLIAM HOLDER*, D. D.
Fellow of the Royal Society, and
late Sub-Dean of their Majesties
Chappel-Royal.

L O N D O N,
Printed, by *J. Heptinstall*, for *John
Carr*; at the *Middle-Temple-Gate*, in
Fleet-street, 1694.

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THE
Natural Grounds and Principles
OF
HARMONY.

The INTRODUCTION.

Harmony consists of Causes, Natural and Artificial, as of Matter and Form. The Material Part of it, is Sound or Voice. The Formal Part is, The Disposition of Sound or Voice into Harmony; which requires, as a preparative Cause, skilfull Composition: and, as an immediate Efficient, Artfull Performance.

The former Part, viz. The Matter, lies deep in Nature, and requires much Research into Natural Philosophy to unfold it; to find how Sounds are made, and

B

how

The Introduction.

how they are first fitted by Nature for Harmony, before they be disposed by Art. Both together make Harmony compleat.

Harmony, then, results from Practick Musick, and is made by the Natural and Artificial Agreement of different Sounds, (viz. Grave and Acute,) by which the Sence of Hearing is delighted.

This is properly in Symphony, i. e. Consent of more Voices in different Tones ; but is found also in solitary Musick of one Voice, by the Observation and Expectation of the Ear, comparing the Habitudes of the following Notes to those which did precede.

Now the Theory in Natural Philosophy, of the Grounds and Reasons of this Agreement of Sounds, and consequent Delight and Pleasure of the Ear, (leaving the Management of these Sounds to the Masters of Harmonick Composure, and the skilfull Artists in Performance) is the Subject of this Discourse. The Design whereof (for the Sake and Service of all Lovers of Musick,

The Introduction.

sick, and particularly the Gentlemen of Their Majesties Chapell Royal) is, to lay down these Principles as short, and intelligible, as the Subject Matter will bear.

Where the first thing Necessary, is a Consideration of somewhat of the Nature of Sound in General; and then, more particularly, of Harmonick Sounds, &c.

CHAP. I.

Of Sound in General.

IN General (to pass by what is not pertinent to this Design) Sense and Experience confirm these following Properties of Sound.

1. All Sound is made by Motion, viz. by Percussion with Collision of the Air.

2. That Sound may be propagated, and carried to Distance, it requires a *Medium* by which to pass.

3. This *Medium* (to our Purpose) is Air.

4. As far as Sound is propagated along the *Medium*; so far also the Motion passeth. For (if we may not say that the Motion and Sound are one and the same thing, yet at least) it is

necessarily consequent, that if the Motion cease, the Sound must also cease.

5. Sound, where it meets with no Obstacle, passeth in a Sphere of the *Medium*, greater or less, according to the Force and Greatness of the Sound : Of which Sphere the sonorous Body is as the Centre.

6. Sound, so far as it reacheth, passeth the *Medium*, not in an Instant, but in a certain uniform Degree of Velocity, calculated by *Gassendus*, to be about the Rate of 276 Paces, in the space of a second Minute of an Hour. And where it meets with any Obstacle, it is subject to the Laws of Reflexion, which is the Cause of Eccho's, Meliorations, and Augmentations of Sound.

7. Sound, *i. e.* the Motion of Sound, or sounding Motion, is carried through the *Medium* or Sphere of Activity, with an *Impetus* or Force which shakes the
free

free *Medium*, and strikes and shakes every Obstacle it meets with, more or less, according to the vehemency of the Sound, and Nature of the Obstacle, and Nearness of it to the Centre, or sonorous Body. Thus the impetuous Motions of the Sound of Thunder, or of a Cannon, shake all before it, even to the breaking of Glass Windows, &c.

8. The Parts of the sounding Body are moved with a Motion of Trembling, or Vibration, as is evident in a Bell or Pipe, and most manifest in the string of a musical Instrument.

9. This Trembling, or Vibration, is either equal and uniform, or else unequal and irregular; and again, swifter or slower, according to the Constitution of the sonorous Body, and Quality and Manner of Percussion; and from hence arise Differences of Sounds.

10. The Trembling, or Vibration

of the sonorous Body, by which the particular Sound is constituted and discriminated, is impressed upon, and carried along the *Medium* in the same Figure and Measure, otherwise it would not be the same Sound, when it arrives at a more distant Ear, *i. e.* the Tremblings and Vibrations (which may be called Undulations) of the Air or *Medium*, are all along of the same Velocity and Figure, with those of the sonorous Body, by which they are caused.

The Differences of Sounds, as of one Voice from another, &c. (besides the Difference of Tune, which is caused by the Difference of Vibrations) arise from the Constitution and Figure, and other Accidents of the sonorous Body.

11. If the sonorous Body be requisitely constituted, *i. e.* of Parts solid, or tense, and regular, fit, being struck, to receive and express the Tremulous
Mo.

Motions of Sound, equally and swiftly, then it will render a certain and even Harmonical Tone or Tune, received with Pleasure, and judged and measured by the Ear : Otherwise it will produce an obtuse or uneven Sound, not giving any certain or discernable Tune.

Now this Tune, or Tuneable sound, *φθόγγον*, i. e. *φωνῆς πλῶσος ἐμμελὴς ἐπὶ μίαν τάσιν*, An agreeable Cadence of Voice, at one Pitch or Tension. This tuneable Sound (I say) as it is capable of other Tensions towards Acuteness, or Gravity, i. e. the Tensions greater or less, the Tune graver or more acute, i. e. lower or higher, is the first Matter or Element of Musick. And this Harmonick Sound comes next to be considered.

C H A P. II.

Of Sound Harmonick.

THE first and great Principle upon which the Nature of Harmonical Sounds is to be found out and discovered, is this : That the Tune of a Note (to speak in our vulgar Phrase) is constituted by the Measure and Proportion of Vibrations of the sonorous Body ; I mean, of the Velocity of those Vibrations in their Recourses.

For, the frequenter the Vibrations are, the more acute is the Tune ; the slower and fewer they are in the same Space of Time, by so much the more grave is the Tune. So that any given Note of a Tune, is made by one certain Measure of Velocity of Vibrations ; viz. Such a certain Number of Courses

Courses and Recourses. e. g. of a Chord or String, in such a certain Space of Time, doth constitute such a certain determinate Tune. And all such Sounds as are Unisons, or of the same Tune with that given Note, though made upon whatsoever different Bodies, (as String, Bell, Pipe, *Larynx*, &c.) are made with Vibrations or Tremblings of those Bodies, all equal each to other. And whatsoever Tuneable Sound is more acute, is made with Vibrations more swift; and whatsoever is more grave, is made with more slow Vibrations: And this is universally agreed upon, as most evident to Experience, and will be more manifest through the whole Theory.

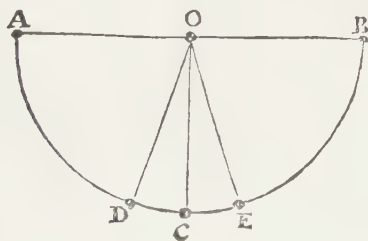
And, That the Continuance of the Sound in the same Tune, to the last, (as may be perceived in Wire-strings, which being once struck will hold their Sound long) depends upon the Equality of Time of the Vibrations, from
the

the greatest Range till they come to cease : And this perfectly makes out the following Theory of Consonancy, and Dissonancy.

Some of the Ancient Greek Authors of Musick, took notice of Vibrations : And that the swifter Vibrations caused acuter, and the slower, graver Tones. And that the Mixture, or not Mixture of Motions creating several Intervals of Tune, was the Reason of their being concord or discord. And likewise, they found out the several Lengths of a Monochord, proportioned to the several Intervals of Harmonick Sounds : But they did not make out the Equality of Measure of Time of the Vibrations last spoken of, neither could be prepared to answer such Objections, as might be made against the Continuity of the sameness of Tune, during the Continuance of the Sound of a String, or a Bell, after it is struck. Neither did any of them offer any Reasons for the
Pro-

Proportions assigned, only it is said, that *Pythagoras* found them out by Chance.

But now, These (since the Acute *Galileo* hath observed, and discovered the Nature of *Pendulums*) are easie to be explained, which I shall do, premising some Consideration of the Properties of the Motions of a *Pendulum*.



Hang a Plumbet C on a String or Wire, fixed at O. Bear C to A: Then let it range freely, and it will move toward B, and from thence swing back towards A. The Motion from A to B, I call the Course, and
back

back from B to A, the Recourse of the *Pendulum*, making almost a Semi-Circle, of which O is the Centre. Then suffering the *Pendulum* to move of it self forwards and backwards, the Range of it will at every Course and Recourse abate, and diminish by degrees, till it come to rest perpendicular at OC.

Now that which *Galileo* first observed, was, that all the Courses and Recourses of the *Pendulum*, from the greatest Range through all Degrees till it came to rest, were made in Equal Spaces of Time. That is, *e.g.* The Range between A and B, is made in the same Space of Time, with the Range between D and E, the Plumbet moving swifter between A and B, the greater Space ; and slower between D and E, the lesser ; in such Proportions, that the Motions between the Terms AB and DE, are performed in Equal Space of time.

And

And here it is to be noted, that where-ever in this Treatise, the swift-ness or slowness of Vibrations is spoke of, it must be always understood of the Frequency of their Courses and Recourses, and not of the Motion by which it passeth from one side to another. For it is true, that the same *Pendulum* under the same Velocity of Returns, moves from one side to the other, with greater or less Velocity, according as the Range is greater or less.

And hence it is, that the Librations of a *Pendulum* are become so excellent, and usefull a Measure of Time; especially when a second Observation is added, that, as you shorten the *Pendulum*, by bringing C nearer to its Centre O, so the Librations will be made proportionably in a shorter Measure of Time, and the Contrary if you lengthen it. And this is found to hold in a Duplicate Proportion of Length to Velocity.

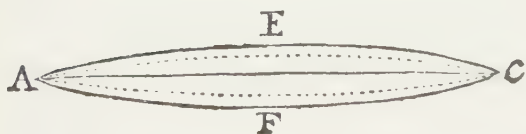
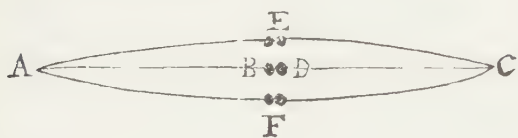
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That is, the Length quadrupled, will subduple the Velocity of Vibrations: And the Length subquadrupled, will duple the Vibrations, for the Proportion holds reciprocally. As you add to the Length of the *Pendulum*, so you diminish the Frequency of Vibrations, and increase them by shortning it.

Now therefore to make the Courses of a *Pendulum* doubly swift, *i. e.* to move twice in the same Space of Time, in which it did before move once; you must subquadruple the Length of it, *i. e.* make the *Pendulum* but a Quarter so long as it was before. And to make the Librations doubly slow, to pass once in the Time they did pass twice; you must quadruple the Length; make the *Pendulum* four Times as long as it was before, and so on in what Proportion you please.

Now to apply this to Musick, make two *Pendulums*, AB and CD, fasten together the Plumbets B and D, and stretch

Stretch them at Length, (fixing the Centers A and C.) Then, being struck, and put into Motion; the Vibrations, which before were Distinct, made by A B, and C D, will now be United (as of one Entire String) both backward and forward, between E and F. Which Vibrations (retaining the aforefaid Analogy to a *Pendulum*) will be made in equal Spaces of Time, from the first to the last; *i. e.* from the greatest Range to the least, until they cease. Now, this being a double *Pendulum*, to Subduple the Swiftneſs of the Vibrations, you do but Double the Length from A to C, which will be Quadruple to A B. The lower Figure is the ſame with that above, only the Plummetts taken off.



C

And

And here you have the Nature of the String of a Musical Instrument, resembling a double *Pendulum* moving upon two Centers, the Nut and the Bridge, and vibrating with the greatest Range in the Middle of its Length; and the Vibrations equal even to the last, which must make it keep the same Tune so long as it sounds. And because it doth manifestly keep the same Tune to the last, it follows that the Vibrations are equal; Confirming one another by two of our Senses: in that we see the Vibrations of a *Pendulum* move equally; and we hear the Tune of a String, when it is struck, continue the same.

The Measure of Swiftneſs of Vibrations of the String or Chord, as hath been ſaid, conſtitutes and determines the Tune, as to Acuteness and Gravity of the Note which it ſounds: And the Lengthning or Shortning of the String, under the ſame Tension, determines

mines the Measure of the Vibrations which it makes. And thus, Harmony comes under Mathematical Calculations of Proportions, of the Length of Chords; of the Measure of Time in Vibrations; of the Intervals of tuned Sounds. As the Length of one Chord to another, *Cæteris paribus*, I mean, being of the same Matter, Thickness and Tension; so is the Measure of the Time of their Vibrations. As the Time of Vibrations of one String to another, so is the Interval or Space of Acuteness or Gravity of the Tune of that one, to the Tune of the other: And consequently, as the Length is (*Cæteris paribus*) so is the determinate Tune.

And upon these Proportions in the Differences, of Lengths, of Vibrations, and of Acuteness and Gravity; I shall insist all along this Treatise, very largely and particularly, for the full Information of all such ingenious Lovers of Musick, as shall have the Curiosity to

inquire into the Natural Causes of Harmony, and of the *Phænomena* which occur therein, though otherwise, to the more learned in Musick and Mathematical Proportions, all might be expressed very much shorter, and still be more shortned by the help of Symbols.

And here we may fix our Foot: Concluding, that what is evident to Sense, of these *Phænomena*, in a Chord, is equally (though not so discernably) true of the Motions of all other Bodies which render a tuneable Sound, as the Trembling of a Bell or Trumpet, the forming of the *Larynx* in our selves, and other Animals, the Throat of Pipes and of those of an Organ, &c. All of them in several Proportions sensibly trembling and impressing the like Undulations of the *Medium*, as is done by the several (more manifest) Vibrations of Strings or Chords.

In these other Bodies, last spoken of,
we

we manifestly see Reason of the Difference of the Swiftneſs of their Vibrations (though we cannot ſo well meaſure them) from their Shape, and other Accidents in their Conſtitution; and chiefly from the Proportions of their Magnitudes; the Greater generally vibrating ſlower, and the Leſs more ſwiftly, which give the Tunes accordingly. We ſee it in the Greatneſs of a String. A greater and thicker Chord will give a graver and lower Tone than one that is more ſlender, of the ſame Tenſion and Length; but they may be made Uniſon by altering their Length and Tenſion.

Tenſion is proper to Chords or Strings (except you will account a Drumm for a Muſical Inſtrument, which hath a Tenſion not in Length, but in the whole Surface) as when we wind up, or let down the Strings, *i. e.* give them a greater or leſs Tenſion, in tuning a Viol, Lute, or Harpſichord,

and is of great Concern, and may be measured by hanging Weights on the String to give it Tension ; but not easily, nor so certainly.

But the Lengths of Chords (because of their Analogy to a *Pendulum*) is chiefly considered, in the Discovery of the Proportions which belong to Harmony, it being most easie to measure and design the Parts of a Monochord, in relation to the whole String ; and therefore all Intervals in Harmony may first be described, and understood, by the Proportions of the Length of Strings, and consequently of their Vibrations. And it is for that reason, that in this Treatise of the Grounds of Harmony, Chords come so much to be considered, rather than other sounding Bodies, & those, chiefly in their Proportions of Length. It is true, that in Wind-Instruments, there is a regard to the Length of Pipes, but they are not so well accommodated (as are Chords) to be

exa-

examined, neither are their Vibrations, nor the Measure of themso manifest.

There are some Musical Sounds, which seem to be made, not by Vibrations but by Pulses, as by whisking swiftly over some Silk or Camblet-stuffs, or over the Teeth of a Comb, which render a kind of Tune more Acute or Grave, according to the Swift-ness of the Motion. Here the Sound is made, not by Vibrations of the same Body, but by Percussion of several Equal, and Equidistant Bodies; as Threads of the Stuff, Teeth of the Comb, passing over them with the same Velocity as Vibrations are made. It gives the same Modification to the Tune, and to the Undulations of the Ayr, as is done by Vibrations of the same Measure; the Multiplicity of Pulses or Percussions, answering the Multiplicity of Vibrations. I take this notice of it, because others have done so; but I think it to be of no use in Musick.

APPENDIX.

Before I conclude this Chapter, it may seem needfull, better to confirm the Foundation we have laid, and give the Reader some more ample Satisfaction about the Motions and Measures of a Pendulum, and the Application of it to Harmonick Motion.

First then, it is manifest to Sense and Experience, and out of all dispute; that the Courses and Recourses return sooner or later, *i. e.* more or less frequently, according as the *Pendulum* is shortned, or made longer. And that the Proportion by which the Frequency increaseth, is (at least) very near duplicate, *viz.* of the Length of the *Pendulum*, to the Number of Vibrations, but is in reverse, *i. e.* as the Length increaseth, so the Vibrations decrease; and contrary, quadruple the Length, and the Vibrations will be subduplicated.

dupled. Subquadruple the Length, and the Vibrations will be dupled. And lastly, that the Librations, the Courses and Recourses of the same *Pendulum*, are all made in equal Space of Time, or very near to it from the greatest Range to the least. Now though the duplicate Proportion assigned, and the Equality of Time, are a little called in question, as not perfectly exact, though very near it ; yet in a Monochord we find them perfectly agree, *viz.* as to the Length, Duple instead of Duplicate, because a String fastened at both Ends is as a double *Pendulum*, each of which is quadrupled by dupling the whole String. And on this duple Proportion, depend all the Rations found in Harmony. And again, the Vibrations of a String are exactly equal, because they continue to give the same Tune.

Supposing then some little Difference may sometime seem to be found
in

in either of these Motions of a *Pendulum*, yet the Nearness to Truth is enough to support our Foundation, by shewing what is intended by Nature, though it sometimes meet with secret Obstacles in the *Pendulum*, which it does not in a well made String. We may justly make some Allowance for the Accidents, and unseen Causes, which happen to make some little Variations in Trials of Motion upon gross Matter, and consequently the like for nicer Experiments made upon the *Pendulum*. It is difficult to find exactly the determinate Point of the Plumbet, which regulates the Motions of the *Pendulum*, and consigns its just Length. Then observe the Varieties which happen through various Sorts of Matter, upon which Experiments are made. *Mersennus* tells us, that heavier Weights of the same Length move slower, so that whilst a Lead Plumbet makes 39 Vibrations, Cork or Wood will make at least

least 40. Again, that a stiff *Pendulum* vibrates more frequently, than that which hangs upon a Chord. So that a Barr of Iron, or Staff of Wood ought to be half as long again as the other, to make the Vibrations equal. Yet in each of these respectively to it self, you will find the duplicate Proportion and Equality of Vibration, or as near as may be. And (as to Equality) though in the Extreame of the Ranges of Librations, viz. the Greatest compared to the Least, there may (from unseen Causes) appear some Difference, yet there is do discernable Difference of the Time of Vibrations of a *Pendulum* in Ranges, that are near to one another, whether greater or less; which is the Case of the Ranges of the Vibration of a String being made in a very small Compass: And therefore the Librations of a *Pendulum*, limited to a small Difference of Ranges, do well correspond with the Vibrations of a String.

As

As to Strings, the Whole of Harmony depends upon this experimented and unquestioned Truth, that Diapason is duple to its Unison, and consequently Diapente is Sesquialterum, Diatesseron Sesquitercium, &c. Yet if you happen to divide a faulty String of an Instrument, you will not find the Octave just in the Middle, nor the other Intervals in their due Proportion, which is no Default in Nature, but in the Matter we apply. A false String is that, which is thicker in one Part of its Length, than in another. The thicker Part naturally vibrates slower, and sounds graver; the more slender Part vibrates swifter, and sounds more acute. Thus whilst two Sounds so near one another, are at once made upon the same String, they make a rough discording Jarr, being a hoarse Tune mixed of both, more or less, as the String is more or less unequal: And if the thicker Part be next the

Frets,

Frets, then the Fret (for example D. F. H. &c. in a Viol or Lute) will render the Tune of the Note too sharp ; and the contrary, if the slender Part of the String be next the Frets ; because in the former, the thicker Part is stopped, and the thinner sounds more of the acuter Part of this unhappy Mixture : As in the latter, the thicker Part is left to sound the graver Tune, and thus the Fret will give a wrong Tune, though the Fault be not in the Fret, but in the String ; which yet, by an unwary Experimenter, may happen to cause the *Sectio Canonis* to be called in question, as well as the Measures of a *Pendulum* are disputed.

But all this does not disprove the Measures found out, and assigned to Harmonick Intervals, which are verified upon a true String or Wire as to their Lengths, and as to the Equality of Recourses in their Vibrations, though *Pendulams* are thought to move slower
in

in their least Ranges ; yet, as to Strings, in the very small Ranges which they make, (which are much less in other Instruments, or sounding Bodies) I need add no more than this, that the Continuance of the same Tune to the last, after a Chord is struck, and the continued Motion in less Vibrations of a sympathizing String, during the Continuance of greater Vibrations of the String which is struck, do either of them sufficiently demonstrate, that those greater or less Vibrations, are both made in the same Measure of Time, according to their Proportions, keeping exact Pace with each other. Otherwise; In the former, the Tune would sensibly alter, and in the latter, the sympathizing String could not be continued in its Motion. This was not so well concluded, till the late Discoveries of the *Pendulum* gave light to it.

There is one thing more which I
must

must not omit. That the Motions of a *Pendulum*, may seem not so proper to explicate the Motions of a String, because the said Motions depend upon differing Principles, *viz.* those of a *Pendulum* upon Gravity; those of a String upon Elasticity. I shall therefore endeavour to shew, how the Motions of a *Pendulum*, agree with those of a Spring, and how properly the Explication of the Vibrations of a String, is deduced from the Properties of a *Pendulum*.

The Elastick power of a Spring, in a Body indued with Elasticity, seems to be nothing else, but a natural Propension and Endeavour of that Body, forced out of its own Place, or Posture, to restore it self again into its former more easie and natural Posture of Rest. And this is found in several Sorts of Bodies, and makes different Cases, of which I shall mention some.

If the Violence be by Compression,
forcing

forcing a Body into less room than it naturally requires; then the Endeavour of Restitution, is by Dilatation to gain room enough. Thus Ayr may be compressed into a less Space, and then will have a great Elasticity, and struggle to regain its room. Thus, if you squeeze a dry Sponge, it will naturally, when you take off the Force, spread it self, and fill its former Place. So, if you press with your Finger a blown Bladder, it will spring and rise again to its Place. And to this may be reduced the Springs of a Watch, and of a Spiral Wire, &c.

Again, a stiff, but pliable Body, fastened at one End, and drawn aside at the other, will spring back to its former Place; this is the Case of Steel-springs of Locks, Snaf-hances, &c. and Branches of Trees, when shaken with the Wind, or pulled aside, return to their former Posture: As is said of the Palm, *Depressa Resurgo*. And there
are

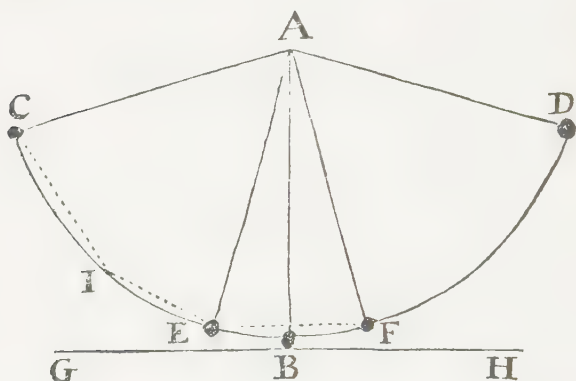
are innumerable instances of this kind, where the Force is by bending, and the Restitution by unbending or returning.

This kind is resembled by a *Pendulum*, or Plummets hanging on a String, whose Gravity, like the Spring in those other Bodies, naturally carries it to its place, which here is downward; all heavy Bodies naturally descending till they meet with some Obstacle to rest upon. And the lowest that the Plummets can descend in its Restraint by the String, is, when it hangs perpendicular, as at A B; where it is nearest to the Horizontal Plane G H, and therefore lowest. Now, if you force the Plummets upward (held at length upon the String) from B to C, and let it go; it will, by a Spontaneous Motion, endeavour its Restitution to B: but, having nothing to stop it but Air, the Impulse of its own Velocity will carry it beyond B, towards D;

D

and

and so backward and forward, decreasing at every Range, till it come to rest at B.



Thus the *Pendulum* and *Spring* agree in Nature, if you consider the Force against them, and their Endeavour of Restitution.

But further, if you take a thin stiff *Lamina* of Steel, like a Piece of Two-penny Ribband of some length, and nail it fast at one End, (the remainder of it being free in the Air) then force the other End aside and let it go; it will make Vibrations backward and forward, perfectly answering those of a Pen-

a *Pendulum*. And much more, if you contrive it with a little Steel Button at the End of it, both to help the Motion when once set on foot, and to bear it better against the Resistance of the Ayr. There will be no difference between the Vibrations of this Spring, and of a *Pendulum*, which in both, will be alike increased or decreased in Proportion to their Lengths. The same End (*viz.* Rest) being, in the same manner, obtained by Gravity in one, and Elasticity in the other.

Further yet, if you nail the Spring above, and let it hang down perpendicular, with a heavier Weight at the lower End, and then set it on moving, the Vibrations will be continued and carried on both by Gravity and Elasticity, the *Pendulum* and the Spring will be most friendly joyned to cause a simple equal Motion of Librations, I mean, an equal Measure of Time in the Recourses ; only the Spring an-

swerably to its Strength, may cause the Librations to be somewhat swifter, as an Addition of Tension does to a String continued in the same length.

I come now to consider a String of an Instrument, which is a Spring fastened at both Ends. It acquireth a double Elasticity. The first by Tension, and the Spring is stronger or weaker, according as the Tension is greater or less. And by how much stronger the Spring is, so much more frequent are the Vibrations, and by this Tension therefore, the Strings of an Instrument keeping the same length are put in Tune, and this Spring draws length-ways, endeavouring a Relaxation of the Tension.

But then, *Secondly*, the String being under a stated Tension, hath another Elastick Power side-ways, depending upon the former, by which it endeavours, if it be drawn aside, to restore it self to the easiest Tension, in the shortest, *viz.* straightest line. In

In the former Case, Tension doth the same with abatement of length, and affects the String properly as a Spring, in that the String being forcibly stretched, as forcibly draws back to regain the remiss Posture in which it was before : And bears little Analogy with the *Pendulum*, except in general, in their spontaneous Motions in order to their Restitution.

But there is great Correspondence in the second Case, between the Librations of a *Pendulum* and the Vibrations of a String (for so, for distinctions sake, I will now call them) in that they are both proportioned to their length, as has been shewn ; and between the Elasticity which moves the String, and Gravity which moves the *Pendulum*, both of them having the same Tendency to Restitution, and by the same Method. As the Declivity of the Motion of a *Pendulum*, and consequently the Impulse of its Gravity is

still lessened in the Arch of its Range from a Semi-Circle, till it come to rest perpendicular ; the Descent thereof being more down-right at the first and greatest Ranges, and more Horizontal at the last and shortest Ranges, as may be seen in the preceding Figure CI IE EB ; so the Impulse of a Spring is still gradually lessened as the Ranges shorten, and as it gains of relaxation, till it come to be restored to rest in its shortest Line. And this may be the Cause of the Equality of Time of the Librations of a *Pendulum*, and also of the Vibrations of a String. Now, the Proportions of Length, to the Velocity of Vibrations in one, and of Librations in the other, we are sure of, and find by manifest Experience to be quadruple in one, and duple in the other.

Now tack two equal *Pendulums* together (as before) being fastened at both Ends, take away the Plumbets,
and

and you make it a String, retaining still the same Properties of Motion, only what was said before to be caused by Gravity, must now be said to be done by Elasticity. You see what an easie Step here is out of one into the other, and what Agreement there is between them. The *Phænomena* are the same, but difficultly experimented in a String, where the Vibrations are too swift to fall under exact Measure; but most easie in a *Pendulum*, whose slow Librations may be measured at pleasure, and numbered by distant Moments of Time.

To bring it nearer, make your Tension of the String by Gravity, instead of screwing it up with a Pegg or Pin: Hang weight upon a Pulley at one End of the String, and as you increase the Weight, so you do increase the Tension, and as you increase the Tension, so you increase the Velocity of Vibrations. So the Vibrations are

proportionably regulated immediately by Tension, and mediately by Gravity. So that Gravity may claim a share in the Measures of these Harmonick Motions.

But to come still nearer, and home to our purpose. Fasten a Gut or Wire-string above, and hang a heavy Weight on it below, as the Weight is more or less, so will be the Tension, and consequently the Vibrations. But let the same Weight continue, and the String will have a stated settled Tension. Here you have both in one, a *Pendulum*, and the Spring of a String, which resembles a double *Pendulum*: Draw the Weight aside, and let it range, and it is properly a *Pendulum*, librating after the Nature of a *Pendulum*. Again, when the Weight is at rest, strike the String with a gentle *Plectrum* made of a Quill, on the upper part, so as not to make the Weight move, and the String will vibrate, and
give

give its Tune, like other Strings fastened at both Ends, as this is also, in this Case. So you have here both a *Pendulum* and a String, or either, which you please. And (the Tension being supposed to be settled under the same Weight) the common Measure and Regulator of the Proportions of them is the Length. And as you alter the Length, so proportionably you alter at once the Velocity in the Recourses of the Vibrations of the String, and of the Librations of the *Pendulum*. And though the Vibrations be so much swifter, and more frequent than the Librations, yet the Ratios are altered alike. If you subduple the Length of the String, then the Vibrations will be dupled. And if you subquadruple it, then the Librations will be also dupled, allowing for so much of the Body of the Weight as must be taken in, to determine the Length of the *Pendulum*.

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The Vibrations are altered in duple Proportion to the Librations, because (as hath been shewn) the String is as a double *Pendulum*, either one of which supposed *Pendulums* is but half so long as the String. and is quadrupled by dupling the whole String. Still therefore the Proportion of their Alterations holds so certainly and regularly with the Proportion of every Change of their common Length, that, if you have the Comparative Ratio of either of these two, *viz.* Vibrations or Librations to the Length, you have them both : The increase of the Velocity of Librations being subduple to the increase of the Velocity of Vibrations. And thus the Motions of a *Pendulum* do fully and properly discover to us, the Motions of a String, by the manifest Correspondence of their Properties and Nature. The *Pendulum's* Motion of Gravity, and the Strings of Elasticity bearing so certain Proportions
accord

according to Length, that the Principles of Harmony, may be very properly made out, and most easily comprehended, as explained by the *Pendulum*. And we find, that in all Ages, this part of Harmony was never so clearly understood, as since the late Discoveries about the *Pendulum*.

And I chuse to make this Illustration by the *Pendulum*, because it is so easie for Experiment, and for our Comprehension; and the Elastick Power so difficult.

Having seen the Origine of Tuneable or Harmonick Sounds, and of their Difference in respect of Acuteness and Gravity : It is next to be considered, how they come to be affected with Consonancy and Dissonancy, and what these are.

C H A P. III.

Of Consonancy and Dissonancy.

C O N S O N A N C Y and D I S S O N A N C Y are the Result of the Agreement, mixture or uniting (or the contrary) of the undulated Motions of the Ayr or *Medium*, caused by the Vibrations by which the Sounds of distinct Tunes are made. And those are more or less capable of such Mixture or Co-incidence according to the Proportion of the Measures of Velocity in which they are made, *i.e.* according as they are more or less commensurate. This I might well set down as a *Postulatum*. But I shall by several Instances endeavour to illustrate the undulating Motions or Undulations of the Ayr; and confirm what is said of their Agreement and Disagreements. And first
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the Undulations, by somewhat we see in other Liquids.

Let a Stone drop into the Middle of a small Pond of standing Water when it is quiet, you shall see a Motion forthwith impressed upon the Water, passing and dilating from that Center where the Stone fell, in circular Waves one within another, still propagated from the Center, spreading till they reach and dash against the Banks, and then returning, if the force of the Motion be sufficient, and meeting those inner Circles which pursue the same Course, without giving them any Check.

And if you drop a Stone in another place, from that Centre will likewise spread round Waves; which meeting the other, will quietly pass them, each moving forwards in its own proper Figure.

The like is better experimented in Quick-silver, which being a more dense

dense Body, continues its Motions longer, and may be placed nearer your Eye. If you try it in a pretty large round Vessel, suppose of a foot Diameter, the Waves will keep their own Motion forward and backward, and quietly pass by one another as they meet. Something of this may be seen in a long narrow Passage, where there is not room to advance in Circles.

Make a wooden Trough or long Box, suppose of two Inches broad, and two deep, and twenty long. Fill it three Quarters or half full of Quick-silver, and place it Horizontally, when it is at quiet, give it with your Finger a little patt at one End, and it will impress a Motion of a ridgid Wave across, which will pass on to the other End, and dashing against it, return in the same Manner, and dash against the hether End, and go back again, and thus backward and forward, till the

the Motion cease. Now if after you have set this Motion on foot, you cause such another, you shall see each Wave keep its regular Course; and when they meet one another, pass on without any Reluctancy.

I do not say these Experiments are full to my purpose, because these being upon single Bodies, are not sufficient to express the Disagreements of Disproportionate Motions caused by different Vibrations of different sounding Bodies; but these may serve to illustrate those invisible Undulations of Air. And how a Voice reflected by the Walls of a Room, or by Echo being of adequate Vibrations, returns from the Wall, and meets the commensurate Undulations passing forwards, without hindring one another.

But there are Instances which further confirm the Reasons of Consonancy and Dissonancy, by the Manifest

feſt agreeing or diſagreeing Measures of Motions already ſpoken of.

It hath been a common Practice to imitate a Tabour and Pipe upon an Organ. Sound together two diſcord- ing Keys (the baſe Keys will ſhew it beſt, becauſe their Vibrations are ſlow- er) let them, for Example, be Ga- mut with Gamut ſharp, or F Faut ſharp, or all three together. Though theſe of themſelves ſhould be exceeding ſmooth and well voyced Pipes ; yet, when ſtruck together, there will be ſuch a Battel in the Ayr between their diſproportioned Motions, ſuch a Clat- ter and Thumping, that it will be like the beating of a Drum, while a Jigg is played to it with the other hand. If you ceaſe this, and ſound a full Cloſe of Concords, it will appear ſurprizingly ſmooth and ſweet, which ſhews how Diſcords well placed, ſet off Concords in Composition. But I bring this Inſtance to ſhew, how ſtrong
and

and vehement these undulating Motions are, and how they correspond with the Vibrations by which they are made.

It may be worth the while, to relate an Experiment upon which I happened. Being in an Arched sounding Room near a shrill Bell of a House Clock, when the Alarm struck, I whistled to it, which I did with ease in the same Tune with the Bell, but, endeavouring to whistle a Note higher or lower, the Sound of the Bell and its cross Motions were so predominant, that my Breath and Lips were check'd so, that I could not whistle at all, nor make any Sound of it in that discording Tune. After, I sounded a shrill whistling Pipe, which was out of tune to the Bell, and their Motions so clashed, that they seemed to sound like switching one another in the Ayr.

Galileo, from this Doctrine of *Pendulums*, easily and naturally explains

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the so much admired sympathy of Consonant strings; one (though untouch'd) moving when the other is struck. It is perceptible in Strings of the same, or another Instrument, by trembling so as to shake off a Straw laid upon the other String: But in the same Instrument, it may be made very visible, as in a Bass-viol. Strike one of the lower Strings with the Bow, hard and strong, and if any of the other Strings be Unison or Octave to it, you shall plainly see it vibrate, and continue to doe so, as long as you continue the Stroke of your Bow, and, all the while, the other Strings which are dissonant, rest quiet.

The Reason hereof is this. When you strike your String, the Progressive sound of it strikes and starts all the other Strings, and every of them makes a Movement in its own proper Vibration. The Consonant string, keeping measure in its Vibrations with those

those of the sounding String hath its Motion continued, and propagated by continual agreeing Pulses or Strokes of the other. Whereas the Remainder of the Dissonant strings having no help, but being checked by the cross Motions of the sounding String, are constrained to remain still and quiet. Like as, if you stand before a *Pendulum*, and blow gently upon it as it passeth from you, and so again in its next Courses keeping exact time with it, it is most easily continued in its Motion. But if you blow irregularly in Measures different from the Measure of the Motion of the *Pendulum*, and so most frequently blow against it, the Motion of it will be so checked, that it must quickly cease.

And here we may take notice, (as hath been hinted before) that this also confirms the aforesaid Equality of the Time of Vibrations to the last, for that the small and weak Vibrations of

the sympathizing String are regulated and continued by the Pulses of the greater and stronger Vibrations of the sounding String, which proves, that notwithstanding that Disparity of Range, they are commensurate in the Time of their Motion.

This Experiment is ancient: I find it in *Aristides Quintilianus* a Greek Author, who is supposed to have been contemporary with *Plutarch*. But the Reason of it deduced from the *Pendulum*, is new, and first discovered by *Galileo*.

It is an ordinary Trial, to find out the Tune of a Beer-glass without striking it, by holding it near your Mouth, and humming loud to it, in several single Tunes, and when you at last hitt upon the Tune of the Glass, it will tremble and Eccho to you. Which shews the Consent and Uniformity of Vibrations of the same Tune, though in several Bodies.

To

To close this Chapter. I may conclude that Consonancy is the Passage of several Tuneable sounds through the *Medium*, frequently mixing and uniting in their undulated Motions, caused by the well proportioned commensurate Vibrations of the sonorous Bodies, and consequently arriving smooth, and sweet, and pleasant to the Ear. On the contrary, Dissonancy is from disproportionate Motions of Sounds, not mixing, but jarring and clashing as they pass, and arriving to the Ear Harsh, and Grating, and Offensive. And this, in the next Chapter shall be more amply explained.

Now, what Concords and Discords are thus produced, and in use, in order to Harmony, I shall next consider.

CHAP. IV.

Of Concords.

Concords are Harmonic sounds, which being joyned please and delight the Ear; and Discords the Contrary. So that it is indeed the Judgment of the Ear that determines which are Concords and which are Discords. And to that we must first resort to find out their Number. And then we may after search and examine how the natural Production of those Sounds, disposeth them to be pleasing or unpleasant. Like as the Palate is absolute Judge of Tasts, what is sweet, and what is bitter, or sower, &c. though there may be also found out some natural Causes of those Qualities. But the Ear being entertained with Motions which fall under exact Demonstrations of their Measures, the
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Doctrine hereof is capable of being more accurately discovered.

First then, (setting aside the Unison Concord, which is no Space or Interval, but an Identity of Tune) the Ear allows and approves these following Intervals, and only these for Concords to any given Note, *viz.* the Octave or Eighth, the Fifth, then the Fourth, (though by later Masters of Musick degraded from his Place) then the Third *Major*, the Third *Minor*, the Sixth *Major*, and the Sixth *Minor*. And also such, as in the Compass of any Voice or Instrument beyond the Octave, may be compounded of these, for such those are, I mean compounded, and only the former Seven are simple Concords ; not but that they may seem to be compounded, *viz.* the greater of the less within an Octave, and therefore may be called Systems, but they are Originals. Whereas beyond an Octave, all is but Repetition of these in Compound with

the Eighth, as a Tenth is an Eighth and a Third ; a Twelfth is an Eighth and a Fifth ; a Fifteenth is Disdiapason, *i.e.* two Octaves, &c.

But notwithstanding this Distinction of Original and Compound Concords ; and, tho' these compounded Concords are found, and discerned by their Habitude to the Original Concords comprehended in the System of Diapason ; (as a Tenth ascending is an Octave above the Third, or a Third above the Octave ; a Twelfth is an Octave to the Fifth, or a Fifth to the Eighth, a Fifteenth is an Eighth above the Octave, *i.e.* Disdiapason two Eighths, &c.) yet they must be own'd, and are to be esteemed good and true Concords, and equally usefull in Melody, especially in that of Consort.

The System of an Eighth, containing seven Intervals, or Spaces, or Degrees, and eight Notes reckoned inclusively, as expressed by eight Chords,

is

is called Diapason, *i. e.* a System of all intermediate Concords, which were anciently reputed to be only the Fifth and the Fourth, and it comprehends them both, as being compounded of them both: And now, that the Thirds and Sixths are admitted for Concords, the Eighth contains them also: *Viz.* a Third *Major* and Sixth *Minor*, and again a Third *Minor* and Sixth *Major*. The Octave being but a Replication of the Unison, or given Note below it, and the same, as it were in Minutire, it closeth and terminates the first perfect System, and the next Octave above it ascends by the same Intervals, and is in like manner compounded of them, and so on, as far as you can proceed upwards or downwards with Voices or Instruments, as may be seen in an Organ, or Harpsichord. It is therefore most justly judged by the Ear, to be the Chief of all Concords, and is the only Consonant System, which
being

being added to it self, still makes Concords.

And to it all other Concords agree, and are Consonant, though they do not all agree to each other ; nor any of them make a Concord if added to it self, and the Complement or Residue of any Concord to Diapason, is also Concord.

The next in Dignity is the Fifth, then the Fourth, Third *Major*, Third *Minor*, Sixth *Major*, and lastly Sixth *Minor* ; all taken by Ascent from the Unison or given Note.

By Unison is meant, sometimes the Habitude or Ration of Equality of two Notes compared together, being of the very same Tune. Sometimes (as here) for the given single Note to which the Distance, or the Rations of other Intervals are compared. As, if we consider the Relations to *Gamut*, to which *A* re is a Tone or Second, *B* mi a Third, *C* a Fourth, *D* a Fifth, &c.

We

We call *Gamut* the Unison, for want of a more proper Word. Thus *C fa ut*, or any other Note to which other Intervals are taken, may be called the Unison.

And the Reader may easily discern, in which Sense it is taken all along by the Coherence of the Discourse.

I come now to consider the natural Reasons, why Concords please the Ear, by examining the Motions by which all Concords are made, which having been generally alledged in the beginning of the third Chapter, shall now more particularly be discussed.

And here I hope the Reader will pardon some Repetition in a Subject, that stands in need of all Light that may be, if, for his easie and more steady Progress, before I proceed, I call him back to a Review and brief Summary of some of those Notions, which have been premis'd and considered more at large. I have shewed,

1. That

1. That Harmonick Sound or Tune is made by equal Vibrations or Tremblings of a Body firly constituted.

2. That those Vibrations make their Courses and Recourses in the same Measure of Time ; from the greatest Range to the lesser, till they come to rest.

3. That those Vibrations are under a certain Measure of Frequency of Courses and Recourses in a given Space of Time.

4. That if the Vibrations be more frequent, the Tune will be proportionably more Acute : if less frequent, more Grave.

5. That the Librations of a *Pendulum* become doubly frequent, if the *Pendulum* be made four times shorter ; and twice slower, if the *Pendulum* be four times longer.

6. That a Chord, or String of a Musical Instrument, is, as a double
Pendu-

Pendulum, or two *Pendulums* tacked together at length, and therefore hath the same Effects by dupling; as a *Pendulum* by quadrupling, *i. e.* by dupling the Length of the Chord, the Vibrations will be subduplicated, *i. e.* be half so many in a given Time. And by subduplicing the Length of the Chord, the Vibrations will be dupled, and proportionably so in all other Measures of Length, the Vibrations bearing a Reciprocal proportion to the Length.

7. That these Vibrations impress a Motion of Undulation or Trembling in the *Medium* (as far as the Motion extends) of the same Measure with the Vibrations.

8. That if the Motions made by different Chords be so commensurate, that they mix and unite; bear the same Course either altogether, or alternately, or frequently: Then the Sounds of those different Chords, thus mixing,
will

will calmly pass the *Medium*, and arrive at the Ear as one Sound, or near the same, and so will smoothly and evenly strike the Ear with Pleasure, and this is Consonancy, and from the want of such Mixture is Dissonancy. I may add, that as the more frequent Mixture or Coincidence of Vibrations, render the Concords generally so much the more perfect : So, the less there is of Mixture, the greater and more harsh will be the Discord.

From the Premises, it will be easy to comprehend the natural Reason, why the Ear is delighted with those forenamed Concords : and that is, because they all unite in their Motions often, and at the least at every sixth Course of Vibration, which appears from the Ratios by which they are constituted, which are all contained within that Number, and all Ratios contained within that Space of Six, make Concords, because the Mixture
of

of their Motions is answerable to the Ration of them, and are made at or before every Sixth Course. This will appear if we examine their Motions. First, how and why the Unisons agree so perfectly ; and then finding the reason of an Octave, and fixing that, all the rest will follow.

To this purpose, strike a Chord of a sounding Instrument, and at the same Time, another Chord supposed to be in all respects Equal, *i. e.* in Length, Matter, Thickness, and Tension. Here then, both the Strings give their Sound ; each Sound is a certain Tune ; each Tune is made by a certain Measure of Vibrations : the same Vibrations are impressed upon, and carried every way along the *Medium*, in Undulations of the same Measure with them, until the Sounds arrive at the Ear. Now the Chords being supposed to be equal in all respects ; it follows, that their Vibrations must be
also

also equal, and consequently move in the same Measure, joyning and uniting in every Course and Recourse, and keeping still the same Equality, and Mixture of Motions of the String, and in the *Medium*. Therefore the Habitude of these two Strings is called Unison, and is so perfectly Consonant, that it is an Identity of Tune, there being no Interval or Space between them. And the Ear can hardly judge, whether the Sound be made by two Strings, or by one.

But Consonancy is more properly considered, as an Interval, or Space between Tones of different Acuteness or Gravity. And amongst them, the most perfect is that which comes nearest to Unison, (I do not mean betwixt which there is the least Difference of Interval : but, in whose Motions there is the greatest Mixture and Agreement next to Unison.) The Motions of two Unisons are in Ratio of 1 to 1, or
of

of Equality. The next Ration in whole Numbers is 2 to 1, Duple. Divide a Monochord in two Equal parts, half the Length compared to the whole, being in Subduple Ration, will make double Vibrations, making two Recourses in the same time that the other makes one, and so uniting and mixing alternately, *i. e.* every other Motion. Then comparing the Sounds of these two, and the half will be found to sound an Octave to the whole Chord. Now the Octave (ascending from the Unison) being thus found and fixed to be in duple Proportion of Vibrations, and subduple of Length ; consequently the Proportions of all other Intervals are easily found out.

They are found out by resolving or dividing the Octave into the mean Rations which are contained in it. *Euclid*, in his *Se&ctio Canonis*, *Theorem. 6.* gives two Demonstrations to prove,

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that

that Duple Ratio contains, and is composed of the two next Ratios, *viz.* *Sesquialtera* and *Sesquitertia*. Therefore an Octave which is in Duple Ratio 2 to 1 is divided into, and composed of a Fifth, whose Ratio is found to be *Sesquialtera* 3 to 2 ; and a Fourth, whose Ratio is *Sesquitertia* 4 to 3. In like manner, *Sesquialtera* is composed of *Sesquiquarta* and *Sesquiquinta*. That is, a Fifth 3 to 2 may be divided into a Third Major 5 to 4, and a Third Minor 6 to 5 ; &c.

There is an easie way to take a view of the Mean Ratios, which may be contained in any Ratio given, by transferring the Prime or Radical Numbers of the given Ratio into greater Numbers of the same Ratio, as 2 to 1 into 4 to 2, or 6 to 3, &c. which have the same Ratio of Duple. Again, 3 to 2 into 6 to 4, which is still *Sesquialtera*. Now in 4 to 2, the Mediety is 3. So that

4 to

4 to 3 and 3 to 2 are comprehended in 4 to 2 ; that is, a Fourth and a Fifth are comprehended in an Eighth. In 6 to 4 the Mediety is 5, so 6 to 4 contains 6 to 5 and 5 to 4 ; *i. e.* a Fifth contains the 2 Thirds. Let 6 to 3 be the Octave, and it contains 6 to 5 Third *less*, 5 to 4 Third *Major*, and 4 to 3, a Fourth, and hath two Medieties, 5 and 4. Of this I shall say more in the next Chapter.

These Ratios express the Difference of Length in several Strings which make the Concords ; and consequently the Difference of their Vibrations. Take two Strings A B, in all other Respects equal, and compare their Lengths, which if equal, make Unison or the same Tune. If A be double in Length to B, *i. e.* 2 to 1, the Vibrations of B will be duple to those of A, and unite alternately, *viz.* at every Course, crossing at the Recourse, and give the Sound of an Octave to A.

If the Length of A be to that of B as 3 to 2, and consequently the Vibrations as 2 to 3, their Sounds will confor in a Fifth, and their Motions unite after every second Recourse, *i. e.* at every other or third Course.

If A to B, be as 4 to 3, they found a Fourth, their Motions uniting after every third Recourse, *viz.* at every fourth Course.

If A to B, be as 5 to 4, they found a Ditone, or third *Major*, and unite after every fourth Recourse, *i. e.* every fifth Recourse.

If A to B, be as 6 to 5, they found a Trihemitone, or Third *Minor*, uniting after every fifth Recourse, at every sixth Course.

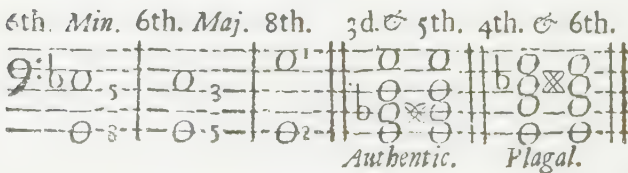
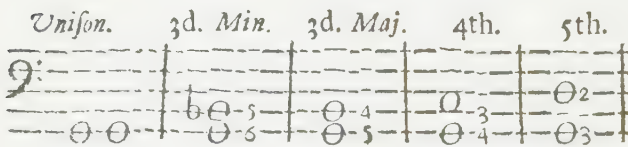
Thus by the frequency of their being mixed and united, the Harmony of joyned Concords is found so very sweet and pleasing; the Remoter being also combined by their Relation to other Concords besides the Unison.

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The greater Sixth, 5 to 3, is within the Compass of Ratios between 1 and 6; but, I confess, the lesser Sixth, 8 to 5, is beyond it: but is the Complement of 6 to 5 to an Octave, and makes a better Concord by its Combinations with the Octave, and Fourth from the Unison; having the Relation of a Third *Minor* to One, and of a Third *Major* to the Other, and their Motions uniting accordingly. And the Sixth *Major* hath the same Advantage. Of these Combinations I shall have occasion to say somewhat more, after I have made the Subject in hand as plain as I can.

I proposed the Collating of two several Strings, to express the Consort which is made by them; but otherwise, these Ratios are more certainly found upon the Measures of a Monochord, taken, by being applied to the Section of a Canon, or a Rule of the Strings length divided into parts, as occasion requires: because there is no need

so often to repeat *Cæteris paribus*, as is when several Strings are collated. And if you take the Rations as Fractions, it will be more easie to measure out the given Parts of a Monochord, or single String extended on an Instrument: Those parts of the String divided by a Moveable Bridge or Fret put under, and made to sound; That Sound, related to the Sound of the Whole, will give the Interval sought after. *Ex. gr.* $\frac{1}{2}$ of the Chord gives an Eighth, $\frac{2}{3}$ give a Fifth, $\frac{3}{4}$ sound a Fourth, $\frac{4}{5}$ sound a Third *Major*, $\frac{5}{6}$ a Third *Minor*, $\frac{3}{5}$ a Sixth *Major*, $\frac{5}{8}$ a Sixth *Minor*: Now we thus express these Concords.



I said, that all Concords are in Rations within the Number Six ; and I may add, that all Rations within the Number Six, are Concords : Of which, take the following Scheme.

6 to 5 3d <i>Minor.</i>	4 to 3 4th	6 to 5 3d <i>Minor.</i>
to 4 5th	to 2 8th	5 to 4 3d <i>Major.</i>
to 3 8th	to 1 15th	4 to 3 4th
to 2 12th	3 to 2 5th	3 to 2 5th
to 1 19th	to 1 12th	2 to 1 8th
5 to 4 3d <i>Major.</i>	2 to 1 8th	
to 3 6th <i>Major.</i>		
to 2 10th <i>Major.</i>		
to 1 17th <i>Major.</i>		

All that are Concords to the Unison, are also Concords to the Octave. And all that are Discords to the Unison, are Discords to the Octave. And some of the Intermediate Concords, are Concords one to another ; as the two Thirds to the Fifth, and the Fourth to the two Sixths. So that the Unison, Third, Fifth, and Octave ; or the Unison, Fourth, Sixth, and Octave, may

be founded together to make a compleat Close of Harmony : I do not mean a Close to Conclude with, for the Plagal is not such ; but a compleat Close, as it includes all Concords within the Compass of Diapason. A Scheme of which I have set down at the End of the foregoing Staff of five Lines, which containeth the Notes by which the aforesaid Concords are expressed. The former two which ascend from the Unison, *Gamut*, by Third *Major* (or *Minor*) and Fifth, up to the Octave ; are usually called Authentick, as relating principally to the Unison, and best satisfying the Ear to rest upon : The other two, which ascend by the Fourth and Sixth *Minor*, (or *Major*) up to the same Octave, are called Plagal, as more combining with the Octave, seeming to require a more proper base Note, *vzi.* an Eighth below the Fourth, and therefore not making a good concluding Close : And on the continual

shifting

shifting these, or often changing them, depends the Variety of Harmony (as far as Consonancy reacheth, which is but as the Body of Musick) in all Contrapunct chiefly, but indeed in all Kinds of Composition. I do not exclude a Sprinkling of Discords ; nor here medle with Ayr, Measure, and Rythmus, which are the Soul and Spirit of Musick, and give it so great a commanding Power. The Plagal Moods descend by the same Intervals, by which the Authentick ascend ; which is by Thirds and Fifths ; and the Authentick descend the same by which the Plagal ascend, *viz.* by Fourths and Sixths ; one chiefly relating to the Unison, the other to the Octave.

But that, for which I described these full Closes, was chiefly, to give (as I promis'd) a larger account of the before-mentioned Combinations of Conords, which increase the Consonancies of each Note, and make a wonderful

derfull Variegation and Delightfulness of the Harmony.

Cast your Eye upon the First of them in the Authentick Scale ; you will see that *Bmi* hath 3 Relations of Consonancy, viz. To the Unison, or given Note *G* ; to the Fifth, and to the Octave : To the Unison as a Third *Minor* ; to the Fifth as a Third *Major* ; to the Octave a Sixth *Major* ; so that its Motions joyn after every fifth Recourse, *i. e.* at every sixth Course, with the Unison ; every fifth with the Diapente or Fifth ; every sixth Course with the Octave. Then consider the Diapente, *D sol re* ; as a Fifth to the Unison, it joyns with it every third Course ; and as a Fourth to the Octave, they joyn every Fourth Course. Then, the Octave with the Unison, joyns after every second Vibration, *i. e.* at every Course.

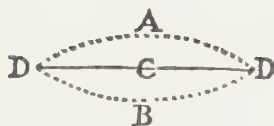
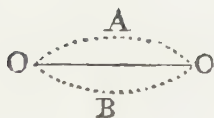
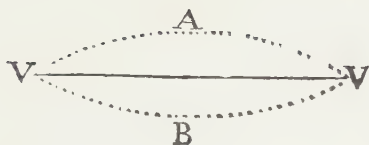
Now take a Review of the Variety of Consonancies in these four Notes. Here are mixed together in one Confort

fort the Rations of 2 to 1, 3 to 2, 4 to 3, 5 to 4, 6 to 5, 5 to 3. And just so it is in the other Closes, only changing alternately the Sixths.

You may see here, within the Space of three Intervals from the Unison, *viz.* 3d, 5th, and 8th; what a Concourse there is of Consonant Rations, to Variegate and give (as it were) a pleasant Purling to the Harmony within that Space. For now, all this Variety is formed within one System of Diapason, justly bearing that Name. But then, think what it will be, when the remote Compounded Concords are joyned to them; as when we make a full Close with both Hands upon an Organ, or Harpsichord, or when the higher Part of a Consort of Musick is reconciled to the lower, by the middle Parts; *viz.* the Treble to the Base, by the Mean and Tenor: And all this, refreshed by the Interchangings made between the Plagal and Authentick

tick Moods. Add to all this, the Infinite Variety of Movement of some Parts, through all Spaces, while some Part moves slowly : And (as in *Fuges*) one part chasing and pursuing another.

The whole Reason of Consonancy, being founded upon the Mixture, and Uniting of the Vibrating Motions of several Chords or sounding Bodies ; it is fit, it should here be better explained and confirm'd. That their Mixtures accord to their Rations, it is easie to be computed : But it may be represented to your Eye.



V	A	B	B	A	A	B	B	A	A	B, &c.
O	AB	BA	AB	BA	AB	BA	AB	BA	AB	BA.

V	AB	BA	AB	BA	AB, &c.
D	ABC	CAB	BAC	CBA	ABC.

Let

Let V V be a Chord, and stand for the Unison : Let O O be a Chord half so long, which will be an Octave to the Unison, and the Vibrations double : Then I say, they will alternately, *i. e.* at every other Vibration unite : Let from A to B, be the Course of the Vibration, and from B to A the Recourse. Observing by the way, that (in relation to the Figures mentioned in this Paragraph and the next, as also in the former Diagram of the *Pendulum*, Cap. 2. pag. 9.) When I say, [from B to A] and, [overtakes V, in A, &c.] I do there endeavour to express the matter brief and perspicuous, without perplexing the Figures with many Lines ; and avoiding the Incumbrance of so many Cautions, whereby to distract the Reader : Yet I must always be understood to acknowledge the continual Decrease of the Range of Vibrations between A and B, while the Motion continues ;

tinues ; and by A and B, mean only the Extremities of the Range of all those Vibrations, both the First greatest, and also the Successive lessened, and gradually contracted Extremities of their Range. And the following Demonstration proceeds and holds equally in both, being applied to the Velocity of Recourses, and not to the Compass of their Range, which is not at all here considered. Such a kind of Equity, I must sometimes in other parts of this Discourse, beg of the Candid Reader. To proceed therefore, I say, whilst V being struck, makes his Course from A to B ; O (struck likewise) will have his Course from A to B, and Recourse from B to A. Next, whilst V makes Recourse from B to A ; O is making its Course contrary, from A to B, but recourseth and overtakes V in A, and then they are united in A, and begin their Course together. So you see, that the Vibrations of Diapason unite
alter.

alternately, joyning at every Course of the Unison, and crossing at the Recourse.

Thus also Diapente or Fifth having the Ration of 3 to 2, unites in like manner at every third Course of the Unison. Let the Chord D D be Diapente to the Unison V; whilst V courseth from A to B, the Chord D courseth from A to B, and makes half his Recourse as far as C; *i. e.* 3 to 2. Whilst V recourses from B to A, D passeth from C to A, and back from A to B. Whilst V courseth again from A to B, D passeth from B to A, and back to C. Whilst V recourses from B to A, D passeth from C to B, and back to A: And then they unite in A, beginning their Courses together, at every third Course of V. In like manner the rest of the Concords unite, at the 4th, 5th, 6th Course, according to their Rations, as might this same way be shewn; but it would take

up too much room, and is needless ; being made evident enough from these Examples already given.

Thus far the Rates and Measures of Consonance lead us on, and give us the true and demonstrable grounds of Harmony : But still it is not compleat without Discords and Degrees (of which I shall treat in another Chapter) intermixed with the Concords, to give them a Foyle, and set them off the better. For, (to use a homely resemblance) That our Food, taken alone, though proper, and wholesome, and natural, may not cloy the Palate, and abate the Appetite ; the Cook finds such kinds and varieties of Sawce, as quicken and please the Palate, and sharpen the Appetite, though not feed the Stomach : As Vinegar, Mustard, Pepper, &c. which nourish not, nor are taken alone, but carry down the Nourishment with better Relish, and assist it in Digestion. So the Practical

G Masters

Masters and Skilful Composers make use of Discords, judiciously taken, to relish the Confort, and make the Concords arrive much sweeter at the Ear, in all sorts of Descant; but most frequently in Cadence to a Close. In all which, the chief regard is to be had to what the Ear may expect in the Conduct of the Composition, and must be performed with Moderation and Judgment; which I now only mention, not intending to treat of Composing, which is out of my Design and Sphear, and would be too large; but my design is, to make these Grounds as plain as I can, thereby to gratifie those, whose Philosophical Learning, without previous Skill in Musick, will easily render them capable of this Theory: And also, those Masters in Practick Musick, and Lovers of it, who, though wanting Philosophy, and the Latin and other Foreign Tongues, to read better Authors;

thors; yet, by the help of their knowledge in Musick, may attain to understand the depth of the Grounds and Reasons of Harmony, for whose sakes it is done in this Language.

I shall conclude this Chapter with some Remarks, concerning the Names given to the several Concords: We call them *Third*, *Fourth*, *Fifth*, *Sixth*, and *Eighth*. Of these, the *Third's* being Two, and *Sixth's* being also Two, want better distinguishing Names. To call them Flat and Sharp Thirds, and Flat and Sharp Sixths is not enough, and lies under a mistake; I mean, it is not a sufficient Distinction, to call the greater Third and Sixth, Sharp Third, and Sharp Sixth; and the lesser, Flat. They are so, indeed, in ascending from the Unison; but in descending they are contrary; for to the Octave, that greater Sixth is a lesser Third, and the greater Third is a lesser Sixth; which lesser Third and Sixth

cannot well be called Flat, being in a Sharp Key; Flat and Sharp therefore do not well distinguish them in General. The lesser Third from the Octave being sharp, and the greater Sixth flat. So, from the Fifth descending by Thirds, if the First be a *Minor* Third, it is Sharp, and the other being a *Major* Third, cannot be said to be Flat.

The other Distinction of them, viz. by *Major* and *Minor*, is more proper, and does well express which of them we mean. But still, the common and confused name of *Third*, if the Distinction of *Major* and *Minor* be not always well remembred, is apt to draw young Practitioners, who do not well consider, into another Errour. I would therefore call the greater Third (as the *Greeks* do) *Ditone*, i. e. of two whole Tones; and the Third *Minor*, *Tribemitone*, or *Sesquitone*, as consisting of three half Tones, (or rather,

ther of a Tone and half a Tone)
And this would avoid the mentioned
Errour which I am going to describe.

It is a Rule in composing Consort
Musick, that it is not lawful to make a
Movement of two Unisons, or two
Eights, or two Fifths together; nor of
two Fourths, unless made good by the
addition of Thirds in another Part:
But we may move as many Thirds
or Sixths together as we please. Which
last is false, if we keep to the same
sort of Thirds and Sixths; for the
two Thirds differ one from ano-
ther in like manner as the Fourth dif-
fers from the Fifth. For in the same
manner as the Eighth is divided into
a Fifth and Fourth: so is a Fifth into a
3d *Major* and 3d *Minor*. Now call
them by their right names, and, I say,
it is not lawful to make a Movement
of as many *Ditones*, or of as many
Sesquitones as you please; and there-
fore when you take the liberty spoken

of, under the general names of *Thirds*, it will be found, that you mix *Ditones* and *Tribemitones*, and so are not concerned in the aforesaid Rule ; and so the Movements of *Sixths* will be made with mixture and interchanges of 6th *Major* and 6th *Minor*, which is safe enough.

Yet, I confess, there is a little more liberty in moving *Tribemitones* and *Ditones*, as likewise, either of the *Sixths*, than there is in moving *Fourths* or *Fifths*; and the Ear will bear it better. Nay, there is necessity, in a gradual Movement of *Thirds*, to make one Movement by two *Tribemitones* together in every *Fourth*, and *Fifth*, or *Fourth disjunct*: That is, twice in *Diapason*, or, at least, in two *Fifths* ; as in *Gamut Key* proper. The natural Ascent will be, *Ut Re Mi Fa Sol La* : Now, to these join *Thirds* in Natural Ascent, and they will be, *Mi Fa Sol La Fa Sol*. $\left\{ \begin{array}{l} \text{Mi Fa Sol La Fa Sol} \\ \text{Ut Re Mi Fa Sol La} \end{array} \right\}$ And thus it will
be

be in other Cliffs, but with some variation, according to the place of the *Hemitone*. Here $\left\{ \begin{smallmatrix} Fa \\ Re \end{smallmatrix} \right\}$ and $\left\{ \begin{smallmatrix} Sol \\ Mi \end{smallmatrix} \right\}$ are two *Tribemitones* succeeding one another, and you cannot well alter them without disordering the Ascent, and disturbing the Harmony ; because, where there is a *Hemitone*, the Tone below joined to it, makes a *Tribemitone*, and the next Tone above it, joined to it, makes the same. Thus you see the necessity of moving two *Tribemitones* together, twice in *Diapason*, or a 9th, in progression of Thirds, in *Diatonic* Harmony, but you cannot well go further.

Now, there is Reason, why two *Tribemitones* will better bear it, because of their different Relations, by which one *Tribemitone* is better distinguished from another, than one Octave, or one Fifth, or one Fourth from another.

In a third *Minor*, which hath two Degrees or Intervals, consisting of a Tone and *Hemitone*, the *Hemitone* may be placed either in the lower Space, and then generally is united to his 3d *Major* (which makes the Complement of it to a Fifth) downward, and makes a sharp Key; or else it may be placed in the upper Space, and then generally takes his 3d *Major* above, to make up the 5th upward, and constitute a Flat Key. And thus a *Tritone* is avoided both ways. I say, if the *Hemitone*, in the 3d *Minor* be below, then the 3d *Major* lies below it, and the Air is sharp. If the *Hemitone* be above, then the 3d *Major* lies above, and the Air is Flat. And thus the two *Minor* Thirds joined in consequence of Movement, are differenced in their Relations, consequent to the place of the *Hemitone*; which variety takes off all Nauseousness from the Movement, and renders it sweet and pleasant.

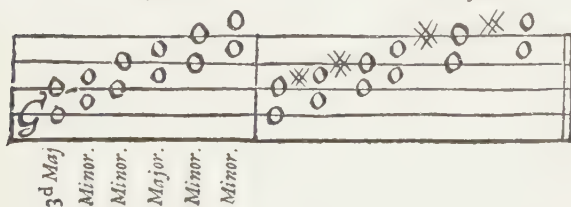
You

You cannot so well and regularly make a Movement of *Ditones*, though it may be done sometimes, once or twice, or more, in a Bearing Passage (in like manner as you may sometimes use *Discords*) to give, after a little grating, a better Relish. The Skilful Artist may go farther in the use of *Thirds* and *Discords*, than is ordinarily allowed.

I might enlarge this Chapter, by setting down Examples of the Lawful and Unlawful Movements of *Thirds Major* and *Minor*, and of the Use of *Discords*; but, as I said before, my design is not to treat of *Composition*: However you may cast your Eye upon these following Instances; and your own Observation from the best Masters will furnish you with the rest.

Lawful Movement
of Thirds, Mix'd.

Unlawful Movement
of Thirds *Major*.



That

That the Reader may not incur any Mistake or Confusion, by several Names of the same Intervals, I have here set them down together, with their Ratios.

8th.	Octave, Diapason.	2	to	1
7th. <i>Major</i> .	Heptachord <i>Major</i> .	15		8
7th. <i>Minor</i> .	Heptachord <i>Minor</i> .	9		5
6th. <i>Major</i> .	Hexachord <i>Major</i> .	5		3
6th. <i>Minor</i> .	Hexachord <i>Minor</i> .	8		5
5th.	Diapente. Pentachord.	3		2
5th. <i>False</i> (in defect.)	} Semidiapente.	64		45
4th. <i>False</i> (in excess.)				
4th.	} Tritone.	45		32
3d. <i>Major</i> .				
4th.	Diateffaron. Tetrachord.	4		3
3d. <i>Major</i> .	Ditone.	5		4
3d. <i>Minor</i> .	} Sefquitone.	6		5
2d. <i>Maj.</i> or Whole note <i>Major</i> .	} Trihemitone.	9		8
2d. <i>Min.</i> or Whole note <i>Minor</i> .	} Semiditone.	10		9
2d. <i>Least</i> , or Half note <i>Greater</i> .				
Half note <i>Less</i> .	} Hemi- tone	16		15
Quarter Note.	} Semi- tone <i>Maj.</i>	25		24
Difference between Tone <i>Major</i> & Tone <i>Minor</i> .	} Hemi- tone <i>Minor</i> .	128		125
	} Diesis Chromatic.	81		80
	} Diesis <i>Major</i> .			
	} Diesis Enharmonic.			
	} Diesis <i>Minor</i> .			
	} Comma. Comma <i>Majus</i> .			
	} Schism.			

Note, Whenever I mention Diesis without Distinction; I mean Diesis *Minor*, or Enharmonic: and when I so mention Comma; I mean Comma *Majus*, or Schism.

I should next treat of Discords, but because there will intervene so much use of Calculation, it is needful that (before I go further) I premise some account of Proportion in General, and apply it to Harmony.

C H A P.

C H A P. V.

Of Proportion ; and Applied to Harmony.

WHereas it hath been said before, That Harmonick Bodies and Motions fall under Numerical Calculations, and the Ratios of Concords have been already assign'd: It may seem necessary here (before we proceed to speak of Discords) to shew the manner how to calculate the Proportions appertaining to Harmonick Sounds: And for this, I shall better prepare the Reader, by premising something concerning Proportion in General.

We may compare (*i. e.* amongst themselves) either (1.) *Magnitudes*, (so they be of the same kind;) Or (2.) the *Gravitations, Motions, Velocities, Durations,*

Durations, Sounds, &c. from thence arising ; or further, if you please, the Numbers themselves, by which the things Compared, are Explicated. And if these shall be Unequal, we may then consider, either, *First*, How much one of them Exceeds the other ; or *Secondly*, After what manner one of them stands related to the other, as to the Quotient of the Antecedent (or former Term) divided by the Consequent (or latter Term :) Which Quotient doth Expound, Denominate, or shew, how many times, or how much of a time, or times, one of them doth contain the other. And this by the *Greeks* is called λόγος, *Ratio* ; as they are wont to call the *Similitude*, or *Equality* of Ratio's, ἀναλογία, *Analogie*, *Proportion*, or *Proportionality*. But Custom, and the Sense assisting, will render any over-curious Application of these Terms unnecessary.

From

From these two Considerations last mention'd, there are wont to be deduced three sorts of Proportion, *Arithmetical*, *Geometrical*, and a mixt Proportion, resulting from these two, called *Harmonical*.

1. *Arithmetical*, When three or more Numbers in Progression, have the same Difference ; as, 2, 4, 6, 8, &c. or discontinued, as 2, 4, 6 ; 14, 16, 18.

2. *Geometrical*, When three or more Numbers have the same Ratio ; as 2, 4, 8, 16, 32 ; or Discontinued ; 2, 4 ; 64, 128.

Lastly, *Harmonical*, (partaking of both the other) When three Numbers are so ordered, that there be the same Ratio of the Greatest to the Least ; as there is of the Difference of the two Greater, to the Difference of the two less Numbers. As in these three Terms ; 3, 4, 6 ; the Ratio of 6 to 3 (being the greatest and least Terms)

Terms) is Duple. So is 2, the Difference of 6 and 4 (the two greater Numbers) to 1. the Difference of 4 and 3 (the two less Numbers) Duple also. This is Proportion Harmonical, which Diapason 6 to 3, bears to Diapente 6 to 4, and Diatessaron 4 to 3 ; as its mean Proportionals.

Now for the kinds of Rations most properly so called ; *i. e.* *Geometrical* ; first observe, that in all Rations, the former Term or Number (whether greater or less) is always called the Antecedent ; and the other following Number, is called the Consequent. If therefore the Antecedent be the greater Term ; then the Ratio is either *Multiplex*, *Superparticular*, *Superpartient*, or (what is compounded of these) *Multiplex Superparticular*, or *Multiplex Superpartient*.

1. *Multiplex* ; as Duple, 4 to 2 ; Triple, 6 to 2 ; Quadruple, 8 to 2.

2. *Super-*

2. *Superparticular* ; as 3 to 2, 4 to 3, 5 to 4 ; Exceeding but by one aliquot part, and in their Radical, or least Numbers, always but by one ; and these Rations are termed *Sesquialtera*, *Sesquitertia*, (or *Supertertia*) *Sesquiquarta* (or *Superquarta*) &c. Note, that Numbers exceeding more than by one, and but by one aliquot part, may yet be *Superparticular*, if they be not expressed in their Radical, *i. e.* least Numbers ; as 12 to 8 hath the same Ration as 3 to 2 ; *i. e.* *Superparticular* ; though it seem not so, till it be reduced by the greatest Common Divisor to its Radical Numbers 3 to 2. And the Common Divisor (*i. e.* the Number by which both the Terms may severally be divided) is often the Difference between the two Numbers ; as in 12 to 8, the Difference is 4, which is the Common Divisor. Divide 12 by 4, the Quotient is 3 ; Divide 8 by 4, the Quotient 2 ; so the Radical
is

is 3 to 2. Thus also 15 to 10, divided by the difference 5, gives 3 to 2; yet in 16 to 10, 2 is the common Divisor, and gives 8 to 5; being *Superpartient*. But in all *Superparticular* Ratios, whose Terms are thus made larger by being Multiplied: the Difference between the Terms is always the greatest common Divisor; as in the foregoing Examples.

The Third kind of Ratio, is *Superpartient*, exceeding by more than One; as 5 to 3, which is called, *Superbipartiens Tertias* (or *Tria*) containing 3 and $\frac{2}{3}$; 8 to 5, *Supertripartiens Quintas*, 5 and $\frac{3}{5}$.

The Fourth is *Multiplex Superparticular*, as 9 to 4, which is Duple, and *Sesquiquarta*; 13 to 4, which is Triple, and *Sesquiquarta*.

The Fifth and last is *Multiplex Superpartient*, as 11 to 4; Duple, and *Supertripartiens Quartas*.

When the Antecedent is less than the Consequent ; viz. when a less is compared to a greater ; then the same Terms serve to express the Rations, only prefixing *Sub* to them, as *Submultiplex*, *Subsuperparticular* (or *Subparticular*) *Subsuperpartient* . (or *Subpartient*) &c. 4 to 2 is *Duple* : 2 to 4 is *Subduple*. 4 to 3 is *Sesquitertia* ; 3 to 4 is *Subsesquitertia* ; 5 to 3 is *Superbipartiens Tertias* ; 3 to 5 is *Subsuperbipartiens Tertias*, &c.

This short account of Proportion was necessary, because almost all the Philosophy of Harmony consists in Rations, Of the Bodies ; Of the Motions ; and of the Intervals of Sound ; by which Harmony is made.

And in searching, stating, and comparing the Rations of these, there is found so much Variety, and Certainty, and Facility of Calculation, that the Contemplation of them may seem not much less delightful, than the

the very hearing the good Musick it self, which springs from this Fountain. And those who have already an affection for Musick, cannot but find it improv'd and much inhanf'd by this pleasant recreating Chase (as I may call it) in the Large Field of Harmonic Rations and Proportions. where they will find, to their great Pleasure and Satisfaction, the hidden causes of Harmony (hidden to most, even to Practitioners themselves) so amply discovered and laid plain before them.

All the Habitudes of Rations to each other, are found by Multiplication or Division of their Terms ; by which any Ration is Added to, or Substracted from another. And there may be use of Progression of Rations ; or Proportions ; and of finding a *Medium*, or *Mediety* between the Terms of any Ration. But the main work is done by Addition, and Sub-

ſtraction of Rations; which, though they are not performed like Addition and Subſtraction of Simple Numbers in Arithmetick; but upon Algebraic Grounds; yet the Praxis is moſt eaſie.

One Ration is added to another Ration, by Multiplying the two Antecedent Terms together, *i. e.* the Antecedent of one of the Rations, by the Antecedent of the other (for the more eaſe, they ſhould be reduc'd into their leaſt Numbers or Terms) And then the two Conſequent Terms in like manner. The Ration of the Product of the Antecedents, to that of the Product of the Conſequents, is equal to the other Two added or joined together. Thus (for Example) Add the Ration of 8 to 6; *i. e.* (in Radical Numbers) 4 to 3, to the Ration of 12 to 10; *i. e.* 6. to 5; the Product will be 24 and 15; *i. e.* 8 to 5; You may ſet them thus,

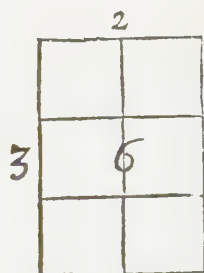
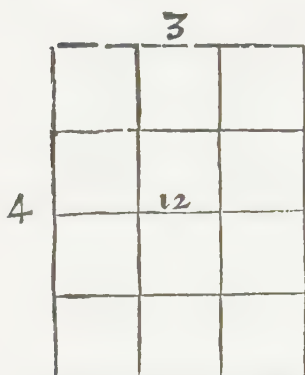
4	3	
6	5	
24.	15.	
		make

make 24, which set at the Bottom ; then multiply 3 by 5, they make 15 ; which likewise set under, and you have 24 to 15 ; which is a Ration compounded of the other two, and Equal to them both. Reduce these Products, 24 and 15, to their least Radical Numbers, which is, by dividing as far as you can find a Common Divisor to them both (which is here done by 3) and that brings them to the Ration of 8 to 5. By this you see, that a Third *Minor*, 6 to 5 ; added to a Fourth, 4 to 3 ; makes a Sixth *Minor*, 8 to 5. If more Rations are to be added, set them all under each other, and multiply the first Antecedent by the Second, and that Product by the Third ; and again, that Product by the Fourth, and so on ; and in like manner the Consequents.

This Operation depends upon the Fifth Proposition of the Eighth Book of *Euclid* ; where He shews, That the

H 3 Ration

Ration of plain Numbers is compounded of their sides. See these Diagrams.



Now compound these Sides. Take for the Antecedents, 4 the greater Side of the greater Plane, and 3 the greater Side of the less Plane, and they multiply'd give 12 ; then take the remaining two Numbers 3 and 2, being the less Sides of the Planes (for Consequents) and they give 6. So, the Sides of 4 and 3, and of 3 and 2 compounded (by multiplying the Antecedent Terms by themselves, and the Consequents by themselves) make 12 to 6 ; *i. e.* 2 to 1. Which being apply'd,

apply'd, amounts to this ; *Ratio Sesquialtera*, 3 to 2, added to *Ratio Sequitertia* 4 to 3 ; makes Duple Ratio, 2 to 1. Therefore *Diapente* added to *Diateffaron*, makes *Diapason*.

Subtraction of One Ratio from another greater, is performed in like manner, by Multiplying the Terms ; but this is done not *Laterally*, as in Addition, but *Crosswise* ; by Multiplying the Antecedent of the Former (*i. e.* of the Greater) by the Consequent of the Latter, which produceth a new Antecedent ; and the Consequent of the Former by the Antecedent of the Latter ; which gives a new Consequent. And therefore it is usually done by an Oblique Decussation of the Lines. For Ex-

ample , If you would take 6 to 5 out of 4 to 3, you may set them down thus. Then 4 multiply'd by 5 makes 20 ; and 3 by 6 gives 18. So 20 to 18 ; *i. e.* 10 to 9, is the Remain-

4	3
X	
6	5
20.	28.
10.	9.
H 4	der.

der. That is, Subtract a Third *Minor* out of a Fourth, and there will remain a Tone *Minor*.

Multiplication of Ratios is the same with their Addition; only it is not wont to be of divers Ratios, but of the same, being taken twice, thrice, or oftener, as you please. And as before, in Addition, you added divers Ratios by Multiplying them: So here, in Multiplication, you add the same Ratio to it self, after the same manner, *viz.* by Multiplying the Terms of the same Ratio by themselves; *i. e.* the Antecedent by it self, and the Consequent by it self (which in other words is to Multiply the same by 2) and will, in the Operation, be to Square the Ratio first propounded (or give the Second Ordinal Power; the Ratio first given being the First Power or Side) And to this Product, if the Simple Ratio shall again be added (after the same manner as before)

the

the Aggregate will be the Triple of the Ration first given; or the Product of that Ration Multiply'd by 3; viz. the Cube, or Third Ordinal Power. Its *Biquadrate*, or Fourth Power, proceeds from Multiplying it by 4; and so successively in order as far as you please you may advance the Powers. For instance, The Duple Ration 2 to 1, being added to it self, Dupled, or Multiply'd by 2, produceth 4 to 1 (the Ration *Quadruple*) and if to this, the first again be added (which is equivalent to Multiplying that said first by 3) there will arise the Ration *Octuple*, or 8 to 1. Whence the Ration 2 to 1, being taken for a Root, its Duple 4 to 1, will be the Square; its Triple 8 to 1, the Cube thereof, &c. as hath been said above. And to use another instance; To Duple the Ration of 3 to 2; it must be thus Squar'd; 3 by 3 gives 9; 2 by 2 gives 4.
So

So the Duple or Square of 3 to 2, is 9 to 4. Agam, 9 by 3 is 27; and 4 by 2 is 8: So the Cubic Ration of 3 to 2 is 27 to 8. Again, to find the Fourth Power, or *Biquadrate*; (*i. e.* Squar'd Square) 27 by 3 is 81; 8 by 2 is 16: So 81 to 16 is the Ration of 3 to 2 Quadrupled; as 'tis Dupled by the Square, Tripled by the Cube, &c. To apply this Instance to our present purpose; 3 to 2 is the Ration of *Diapente*, or a Fifth in Harmony; 9 to 4 is the Ration of twice *Diapente*, or a Ninth (*viz.* *Diapason* with *Tone Major*) 27 to 8 is the Ration of thrice *Diapente*, or three Fifths; which is *Diapason* with *Six Major* (*viz.* 13th *Major*) The Ration of 81 to 16 makes four Fifths, *i. e.* *Dis-diapason*, with two *Tones Major*; *i. e.* a *Seventeenth Major*, and a *Comma* of 81 to 80.

To

To Divide any Ration, you must take the contrary way ; And by Extracting of these Roots Respectively , Division by their *Indices* will be performed. *E. gr.* To Divide it by 2, is to take the Square Root of it ; by 3, the Cubic Root ; by 4, the Biquadratick, &c. Thus to divide 9 to 4, by 2 ; The Square Root of 9, is 3 ; the Square Root of 4, is 2 : Then 3 to 2 is a Ration just half so much as 9 to 4.

From hence it will be obvious to any to make this Inference ; That Addition and Multiplication of Rations are (in this Case) one and the same thing. And these Hints will be sufficient to such as bend their Thoughts to these kinds of Speculations, and no great Trespas upon those that do not.

The Advantage of proceeding by the Ordinal Powers, Square, Cube, &c. (as is before mentioned) may be very usefull where there is occasion of
large

large Progressions. As to find (for Example) how many Comma's are contained in a Tone *Major*, or other Interval. Let it be, How many are in Diapason ; Which must be done by Multiplying Comma's ; *i. e.* Adding them, till you arrive at a Ration Equal to Octave (if that be sought) *viz.* Duple. Or else by Dividing the Ration of Diapason, by that of a Comma, and finding the Quotient ; which may be done by Logarithms. And herein I meet with some Differences of Calculations.

Mersennus finds, by his Calculation, $58\frac{1}{2}$ Comma's, and somewhat more in an Octave. But the late *Nicholas Mercator*, a Modest Person, and a Learned and Judicious Mathematician, in a Manuscript of his, of which I have had a Sight ; makes this Remark upon it. *In solvendo hoc Problemate aberrat Mersennus.* And He, working by the Logarithms, finds out
but

but 55, and a little more. And from thence has deduced an Ingenious Invention of finding and applying a least Common Measure to all Harmonic Intervals; not precisely perfect, but very near it.

Supposing a Comma to be $\frac{1}{53}$ part of Diapason; for better Accommodation rather than according to the true Partition $\frac{1}{55}$; which $\frac{1}{53}$ he calls an Artificial Comma, not exact, but differing from the true Natural Comma about $\frac{1}{20}$ part of a Comma, and $\frac{1}{1000}$ of Diapason (which is a Difference imperceptible) Then the Intervals within Diapason will be measured by Comma's according to the following Table. Which you may prove by adding two, or three, or more of these Numbers of Comma's, to see how they agree to constitute those Intervals, which they ought to make; and the like by subtracting.

Intervals

Intervals	$\frac{0}{53}$	Intervals	$\frac{0}{53}$
<i>Comma</i>	1	4 th	22
<i>Diesis</i>	2	<i>Tritone</i>	26
<i>Semit. Minus</i>	3	<i>Semidiapente</i>	27
<i>Semit. Medium</i>	4	5 th	31
<i>Semit. Majus</i>	5	6 th <i>Minor</i>	36
<i>Semit. Max.</i>	6	6 th <i>Major</i>	39
<i>Tone Minor</i>	8	7 th <i>Minor</i>	45
<i>Tone Major</i>	9	7 th <i>Major</i>	48
3 ^d <i>Minor</i>	14	<i>Octave</i>	53
3 ^d <i>Major</i>	17		

This I thought fit, on this occasion, to impart to the Reader, having leave so to doe from Mr. *Mercator's* Friend to whom He presented the said Manuscript.

Here I may advertise the Reader ; that it is indifferent whether you compare the greater Term of an Harmonic Ration to the less, or the less to the greater ;

greater; *i.e.* whether of them you place as Antecedent. *E.gr.* 3 to 2, or 2 to 3. Because in Harmonics, the proportions of Lengths of Chords, and of their Vibrations are reciprocal or Counter-changed. As the Length is increased, so the Vibrations are in the same proportion decreased; & *à contra*. If therefore (as in *Diapente*) the length of the Unison String be 3, then the length (*ceteris paribus*) of the String which in ascent makes *Diapente* to that Unison must be 2, or $\frac{2}{3}$. Thus the Ratio of *Diapente* is 2 to 3 in respect of the length of it, compared to the length of the Unison String.

Again, the String 2 vibrates thrice, in the same time that the String 3 vibrates twice. And thus the Ratio of *Diapente* in respect of Vibrations is 3 to 2. So that where you find in Authors, sometimes the greater Number in the Ratios set before and made the Antecedent, sometimes set after
and

and made the Consequent; You must understand in the former, the Ratio of their Vibrations; and in the latter, the Ratio of their Lengths; which comes all to one.

Or you may understand the Unison to be compared to *Diapente* above it, and the Ratio of Lengths is 3 to 2; of Vibrations 2 to 3: or else *Diapente* to be compared to the Unison, and then the Ratio of Lengths is 2 to 3; of Vibrations 3 to 2. This is true in single Ratios, or if one Ratio be compared to another; then the two Greater Terms must be ranked as Antecedents: or otherwise, the two Less Terms.

The Difference between Arithmetical and Geometrical Proportion is to be well heeded. An Arithmetical mean Proportion is that which has Equal difference to the Antecedent and Consequent Terms of those Numbers to which it is the Mediety; and

is found by adding the Terms and taking half the Sum. Thus between 9 and 1, which added together make 10, the Mediety is 5 ; being Equidifferent from 9 and from 1 ; which Difference is 4 : As 5 exceeds 1 by 4 ; so likewise 9 exceeds 5 by 4. And thus in Arithmetical Progression 2, 4, 6, 8 ; where the Difference is onely considered, there is the same Arithmetical Proportion between 2 and 4, 4 and 6, 6 and 8 ; and between 2 and 6, and 4 and 8. But in Geometrical Proportion where is considered, not the Numerical Difference, but another Habitude of the Terms, *viz.* How many times, or how much of a time, or times, one of them doth contain the other (as hath been explained at large in the beginning of this Chapter.) There the Mean Proportional is not the same with Arithmetical, but found another way ; and Equidifferent Progressions make different Ratios. The Ratios

(taking them all in their least Terms)
 expressed by less Numbers, being greater than those of greater Numbers, I mean in Proportions *Super-particular*, &c. Where the Antecedents are Greater than the Consequents: (as on the Contrary, where the Antecedents are Less than the Consequents, the *Ratio's* of Less Numbers are Less than the *Ratio's* of Greater.) The Mediety of 9 to 1, is not now 5, but 3; 3 having the same Ratio to 1, as 9 has to 3 (as 9 to 3, so 3 to 1) *viz.* Triple. And so in Progression Arithmetical, of Terms having the same Differences; if considered Geometricaly, the Terms will all be comprehended by unequal Ratios. The Differences of 2 to 4, 4 to 6, 6 to 8, are Equal; but the Ratios are unequal: 2 to 4 is less than 4 to 6, and 4 to 6 less than 6 to 8. As on the Contrary; 4 to 2, is greater than 6 to 4; and 6 to 4 greater than 8 to 6. For 4 to 2
 is

is Dupie; 6 to 4 but *Sesquialtera* (one and a half onely, or $\frac{3}{2}$) and 8 to 6 is no more than *Sesquitertia*, (one and a Third part, or $\frac{4}{3}$) which shews a considerable Inequality of their Ratios. In like manner, 6 to 2 is Triple; 8 to 4 is but Duple; and yet their Differences Equal. Thus the mean Ratios comprehended in any greater Ratio divided Arithmetically; *i. e.* by Equal Differences; are unequal to one another considered Geometrically. Thus 2, 3, 4, 5, 6; if you consider the Numbers, make an Arithmetical Progression: But if you consider the Ratios of those Numbers, as is done in Harmony, then they are Unequal; every one being greater or less (according as you proceed by Ascent or Descent) than the next to it. Thus in this progression, 2 to 3 is the greatest, being *Diapente*; 3 to 4 the next, *Diateffaron*; 4 to 5 still less, *viz.* *Ditone*; 5 to 6 the least, being *Sesquitone*. Or, if you descend,

cend, 6 to 5 least ; 5 to 4 next, &c. These are the mean Ratios comprehended in the Ratio of 6 to 2, by which *Diapason cum Diapente*, or a 12th, is divided into the aforesaid Intervals, and measured by them : *viz.* as is 6 to 2, (*viz.* Triple.) So is the Aggregate of all the mean Ratios within that Number ; 6 to 5, 5 to 4, 4 to 3, and 3 to 2. Or 6 to 5, 5 to 2 ; or 6 to 4, 4 to 2 ; or 6 to 3, 3 to 2. The Aggregates of these are Equal to 6 to 2, *viz.* Triple.

This is premised in order to proceed to what was intimated in the foregoing Chapter.

Taking notice first of this procedure, peculiar to Harmonics ; *viz.* To make Progression or Division in Arithmetical Proportion in respect of the Numbers ; but to consider the things Numbred according to their Ratios Geometrical. And thus Harmonic proportion, is said to be compounded of Arithmetical and Geometrical. You

You may find them all in the Division of the Systeme of *Diapason*, into *Diapente* and *Diateffaron*, i. e. 5th and 4th ; ascending from the Unison.

If by *Diapente* first, Then by 2, 3, 4, Arithmetically : If first by *Diateffaron*, Then by 3, 4, 6, Harmonically. And these Ratios considered Geometrically, in Relation to Sound ; There is likewise found Geometrical Proportions between the Numbers 6, 3, to 4, 2 ; and 6, 4, to 3, 2.

The Antients therefore owning only 8th, 5th, and 4th, for Simple Consonant Intervals ; concluded them all within the Numbers of 12, 9, 8, 6, which contained them all : viz. 12 to 6, *Diapason* ; 12 to 8, *Diapente* ; 12 to 9, *Diateffaron* ; 9 to 8, *Tone*. And which served to express the three Kinds of Proportion ; viz. Harmonical, between 12 to 8, and 8 to 6 ; Arithmetical, between 12 to 9, and 9 to 6 ; and Geometrical, between 12 to 9, and 8 to 6 ;

I 3

and

and between 12 to 8, and 9 to 6. It was said therefore, That *Mercurius* his Lyre was strung with four Chords, having those Proportions, 6, 8, 9, 12. *Gassend.*

I intimated that I would here more largely explain that ready and easie way of finding and measuring the mean Rations contained in any of those Harmonick Rations given, by transferring them out of their Prime or Radical Numbers, into greater Numbers of the same Ration. By Dupling (not the Ration, but the Terms of it: still continuing the same Ration) you will have one Mediety: as 2 to 1 Dupled is 4 to 2; and you have 2 the Mediety. By Tripling you will have two Means; 2 to 1 Tripled is 6 to 3, containing 2 Rations; 6 to 5, 5 to 4, 4 to 3; and so still more, the more you multiply it.

Now observe, First, That any Ration *Multiplex* or *Superpartient* (or by trans-

transferring it out of its Radical Numbers made like *Superpartient*) contains so many *Superparticular* Rations, as there are Units in the Difference between the Antecedent and the Consequent. Thus in 8 to 4 (being 2 to 1 transferred by Quadrupling) the Difference is 4, and it contains 4 *Superparticular* Rations ; viz. 8 to 7, 7 to 6, 6 to 5, and 5 to 4. Where though the Progression of Numbers is Arithmetical, yet the Proportions of excess are Geometrical and Unequal. The *Superparticular* Rations expressed by less Numbers, being Greater, as hath been said, than those that consist of Greater Numbers ; 5 to 4 is a Greater Ration than 6 to 5, and 6 to 5 Greater than 7 to 6, and 7 to 6 than 8 to 7 ; as a Fourth part is Greater than a Fifth, and a Fifth Greater than a Sixth, &c. But in this Instance, there are two Rations not appertaining to Harmonics ; viz. 8 to 7, and 7 to 6.

Secondly therefore, you may make unequal Steps, and take none but Harmonick Rations, by Selecting Greater and fewer intermediate Rations, tho' some of them composed of several *Superparticulars*; provided you do not discontinue the Rational Progression, but that you repeat still the last Consequent, making it the next Antecedent. As if you measure the Ratio of 8 to 4, by 8 to 6, and 6 to 4; or by 8 to 5, and 5 to 4; or by 8 to 6, and 6 to 5, and 5 to 4. In these three ways the Ratios are all Harmonical, and are respectively contained in, and make up the Ratio of 8 to 4. Thus you may measure, and divide, and compound most Harmonick Ratios without you Pen.

To that End, I would have my Reader to be very perfect in the Radical Numbers, which express the Ratios of the Seven first (or uncompounded) Consonants: *viz.* *Diapason*, 2 to 1; *Dia-*

Diapente, 3 to 2 ; *Diateffaron*, 4 to 3 ;
Ditone, 5 to 4 ; *Tribemitone*, 6 to 5 ;
Hexachordon Majus, 5 to 3 ; *Hexa-*
chordon Minus, 8 to 5. And likewise
of the Degrees in Diatonick Harmony,
viz. *Tone Major*, 9 to 8 ; *Tone Minor*,
10 to 9 ; *Hemitone Major*, 16 to 15.
And the Differences of those Degrees ;
Hemitone Greatest, 27 to 25 ; and *He-*
mitone Minor, 25 to 24 ; *Comma*, or
Schism, 81 to 80 ; *Diesis Enharmonic*,
128 to 125.

Of other *Hemitones*, I shall treat in
the Eighth Chapter.

Now if you would divide any of
the Consonants into two Parts, you
may do it by the Mean, or Mediety
of the two Radical Numbers ; if they
have a Mean : And where they have
not (as when their *Ratio's* are *Super-*
particular) you need but Duple those
Numbers, and you will have a Mean
(one or more.) Thus Duple the Num-
bers of the Ration of *Diapason*, 2 to 1 ;
and

and you have 4 to 2 ; and then 3 is the Mean by which it is divided into two Unequal, but Proper and Harmonical parts ; viz. 4 to 3, and 3 to 2. After this manner *Diapason*, 4 to 2 ; comprehends 4 to 3, and 3 to 2. So *Dia-pente*, 6 to 4 ; is 6 to 5, and 5 to 4. *Ditone*, 10 to 8 ; is 10 to 9, and 9 to 8. So *Sixth Major*, 5 to 3 ; is 5 to 4, and 4 to 3.

Though, from what was now observ'd, you may divide any of the Consonants into intermediate Parts ; yet when you divide these three following, viz. *Sixth Minor*, *Diatessaron*, and *Tribemitone* ; you will find that those Parts into which they are divided, are not all such Intervals as are Harmonical. The *Sixth Minor*, whose Ration is 8 to 5, contains in it three Means ; viz. 8 to 7, 7 to 6, and 6 to 5 ; the last whereof onely is one of the Harmonick Intervals, of which the *Sixth Minor* consists ; viz. *Tribemitone* : and

to make up the other Interval, viz. *Diateffaron* ; you must take the other two, 8 to 7, and 7 to 6 ; which being added (or, which is the same thing, taking the *Ratio* of their two Extream Terms, *That* being the Sum of all the Intermediate ones added) you have 8 to 6, or (in the least Terms) 4 to 3. Again *Diateffaron*, in Radical Numbers, 4 to 3 ; being (if those Numbers are dupled) 8 to 6, gives for his Parts, 8 to 7, and 7 to 6 ; which *Ratio's* agree with no Intervals that are Harmonick. Therefore you must take the *Ration* of *Diateffaron* in other Terms, which may afford such Harmonick Parts. And to do this, you must proceed farther than dupling (or adding it once to it self) for to this Duple you must add the first Radical Numbers once again (which in effect is the same with Tripling it at first) viz. 4 and 3, to 8 and 6 ; and the Aggregate will be a
new,

new, but Equivalent, Ratio of *Diateffaron*; viz. 12 to 9. And this gives you three Means, 12 to 11, and 11 to 10; both Unharmonical; but, which together are, as was shewed before, the same with 12 to 10 (or 6 to 5) *Trihemitone*; and 10 to 9, *Tone Minor*: and are the two Harmonical Intervals of which *Diateffaron* consists, and which divide it into the two nearest Equal Harmonick Parts. Lastly *Trihemitone*, or *Third Minor*, 6 to 5; or (those Numbers being dupled) 12 to 10, gives 12 to 11, and 11 to 10; which are Unharmonical Ratios: but Tripled (after the former manner) 6 to 5 gives 18 to 15; which divides it self (as before) into 18 to 16, *Tone Major*; and 16 to 15, *Hemitone Major*.

Thus by a little Practice all Harmonick Intervals will be most easily measured, by the lesser Intervals comprized in them. Now, (for exercise sake)

take) take the Measures of a greater Ration : Suppose that of 16 to 3 be given as an Harmonick Systeme. To find what it is, and of what Parts it consists : First find the gross Parts, and then the more Minute. You will presently judge, that 16 to 8 (being a Part of this Ration) is *Diapason*; and 8 to 4 is likewise *Diapason*: then 16 to 4 is *Disdiapason*, or a Fifteenth; and the remaining 4 to 3, is a Fourth. So then, 16 to 3, is *Disdiapason*, and *Diateffaron*; i. e. an Eighteenth : 16 to 8, 8 to 4, and 4 to 3.

But

But to find all the Harmonick Intervals within that Ration (for we now consider Rations as relating to Harmony) take this Scheme.

16 to 3 contains,

In Radicals.

16 to 15,		<i>Hemitone.</i>
15 to 12,	5 to 4,	<i>Ditone.</i>
12 to 10,	6 to 5,	<i>Tribemitone.</i>
10 to 9,		<i>Tone Minor.</i>
9 to 8,		<i>Tone Major.</i>
8 to 6,	4 to 3,	<i>Diateffaron.</i>
6 to 5,		<i>Tribemitone.</i>
5 to 4,		<i>Ditone.</i>
4 to 3,		<i>Diateffaron.</i>
<i>Tot. 16 to 3.</i>		<i>Disdiapason cum Diateffaron.</i>

Or Thus,

In Radicals.

16 to 10,	8 to 5,	6th <i>Minor.</i>
10 to 6,	5 to 3,	6th <i>Major.</i>
6 to 4,	3 to 2,	5th
4 to 3,		4th
<i>Tot. 16 to 3.</i>		<i>Eighteenth.</i>

All

All these Intervalls thus put together are comprehended in, and make up the Ratio of 16 to 3; being taken in a Conjunct Series of Ratios.

But otherwise, within this Compass of Numbers are contained many more Expressions of Harmonick Relation. *Ex. gr.*

<i>Radicals.</i>		<i>Radicals.</i>	
16 to 15.		12 to 6,	2 to 1.
16 to 12,	4 to 3.	12 to 4,	3 to 1.
16 to 10,	8 to 5.	12 to 3,	4 to 1.
16 to 8,	2 to 1.	10 to 9.	
16 to 6,	8 to 3.	10 to 8,	5 to 4.
16 to 4,	4 to 1.	10 to 6,	5 to 3.
16 to 3.		10 to 5,	2 to 1.
15 to 12,	5 to 4.	9 to 8.	
15 to 10,	3 to 2.	9 to 6,	3 to 2.
15 to 5,	3 to 1.	9 to 3,	3 to 1.
15 to 3,	5 to 1.	8 to 6,	4 to 3.
14 to 7,	2 to 1.	8 to 5,	
12 to 10,	6 to 5.	8 to 4,	2 to 1.
12 to 9,	4 to 3.	6 to 5, &c.	
12 to 8,	3 to 2.	<i>Vid. Pag. 67.</i>	

And now I suppose the Reader better prepared to proceed in the remainder of this Discourse, where we shall treat of Discords.

C H A P. VI.

Of Discords and Degrees.

ALL Habitudes of one Chord to another, that are not Concords (such as are before described) are Discords; which are, or may be innumerable, as are the minute Tensions by which one Chord may be made to vary from it self, or from another. But here we are to consider onely such Discords as are useful (and in truth necessary) to Harmony, or at least relating to it, as are the Differences found between Harmonick Intervals.

And these apt and useful Discords, are either Simple uncompounded Intervals, such as immediately follow one another, ascending or descending
in

in the Scale of Music : As *Ut Re Mi. Fa Sol La Fa Sol*, and are called Degrees : Or else, greater Spaces or Intervals compounded of Degrees including or skipping over some of them, as all the Concords do, *Ut Mi, Ut Fa, Ut Sol*, &c. And such are the Discords of which we now treat, as principally the *Tritone*, False Fifth, and the two *Sevenths* ; *Major*, and *Minor*, if they be not rather among the Degrees, &c. For more perspicuity I shall treat of them severally ; viz. of Degrees, of Discords, and of Differences.

And First of Degrees.

Degrees, are uncompounded Intervals, which are found upon 8 Chords and in 7 Spaces, by which an immediate Ascent or Descent is made from the *Unison* to the *Octave* or *Diapason* ; and by the same progression to as many *Octaves* as there may be occasion.

K

These

These are different, according to the different Kinds of Music; viz. *Enharmonic*, *Chromatic*, and *Diatonic*, and the several Colours of the two Latter: (All which I shall more conveniently explain by and by.) But of these now mentioned, the *Diatonic* is the most Proper and Natural Way: The other two, if for Curiosities sake we consider them only by running the Notes of an *Octave* up or down in these Scales, seem rather a force upon Nature; yet herein probably might lye the Excellency of the Ancient *Greeks*. But we now use only the *Diatonic* kind, intermixing here and there some of the *Chromatic*, (and more rarely some of the *Enharmonic* :) And our Excellency seems to lye in most artificial Composing, and joyning several parts in Symphony or Consort; which they cannot be supposed to have effected, at least in so many Parts as we ordinarily make; because (as is generally

rally affirmed of them) they owned no Concords, besides Eighth, Fifth, and Fourth, and the Compounds of these.

F. Kircher (cited also by *Gassendus* without any Mark of Dissent) is of Opinion, That the Ancient *Greeks* never used Consort Music, *i. e.* of different Parts at once ; but only Solitary, for one single Voice, on Instrument. And that *Guido Aretinus* first invented and brought in Music of Symphony or Consort both for the one and the other. They applyed Instruments to Voice, but how they were managed, He must be wiser than I, that can tell.

This way of theirs seems to be more proper (by the Elaborate Curiosity and Nicety of Contrivance of Degrees, and by Measures, rather than by Harmonious Consonancy, and by long studied performance) to make great Impressions upon the Fancy, and operate accordingly, as some Histories

relate : Ours, more Sedately affects the Understanding and Judgment from the judicious Contrivance, and happy Composition of Melodious Consort. The One quietly, but powerfully affects the Intellect by true Harmony: The Other, chiefly by the *Rythmus*, violently attacks and hurries the Imagination. In fine, upon the Natural Grounds of Harmony (of which I have hitherto been treating) is founded the *Diatonic* Music ; but not so, or not so regularly, the *Chromatic* and *Enharmonic* kinds. Take this following view of them.

The Ancients ascended from the *Unison* to an *Octave* by two Systemes of Tetrachords or Fourths. These were either Conjunct, when they began the Second Tetrachord at the Fourth Chord ; viz. with the last Note of the First Tetrachord ; and which being so joyned, constituted but a Seventh: And therefore they assumed a *Tone* beneath

neath the *Unison* (which they therefore called *Proslambanomenos*) to make a full Eighth.

Or else the two Tetrachords were disjunct ; the Second taking its beginning at the Fifth Chord ; there being always a *Tone Major* between the Fourth and Fifth Chords. So, the Degrees were immediately applied to the 4^{ths}, and by them to the *Octave* ; and were different according to the different Kinds of Music. In the common *Diatonic Genus*, the Degrees were *Tone* and *Semitone* ; Intervals more Equal and Easy, and Natural. In the common *Chromatic*, where the Degrees were *Hemitones* and *Trihemitones* ; the Difference of some of the Intervals was Greater. But the Greatest Difference, and consequently Difficulty, was in the *Enharmonic* Kind, using only *Diesis*, or Quarter of a *Tone*, and *Ditone* ; as the Degrees whereby they made the Tetrachord.

And to constitute these Degrees, some of them, *viz.* the Followers of *Aristoxenus*, divided a *Tone Major* into 12 Equal Parts; *i.e.* Supposed it so divided: Six of which being the *Hemitone*, (*viz.* half of it,) made a Degree of *Chromatic Tonium*. And Three of them, or a Quarter called *Diesis*; a Degree *Enharmonic*. The *Chromatic Fourth* rose thus, *viz.* from the First Chord to the Second was a *Hemitone*; from the Second to the Third, a *Hemitone*; from the Third to the Fourth, a *Trihemitone*; or as much as would make up a just Fourth. And this last Space (in this case) was accounted as well as either of the other, but one Degree or undivided Interval. And they called them *Spiss* Intervals (*πυκνὰ*) when two of those other Degrees put together, made not so great an Interval as one of these; as, in the *Enharmonic Tetrachord*, two *Dieses* were less than the remaining *Ditone*, and in the

com-

common *Chromatic*, two *Hemitone* Degrees were less than the remaining *Trihemitone* Degree.

Then for the *Enharmonic* Fourth, the first Degree was a *Diesis*, or Quarter of a *Tone*; the Second also 3 of those 12 parts, *viz.* a *Diesis*; the Third a *Ditone*; such as made up a just Fourth. And this *Ditone*, (though so large a Degree) being considered as thus placed (in the *Enharmonic* Tetrachord) was likewise to them but as one uncompounded or entire Interval.

These were the Degrees *Chromatic*, and *Enharmonic*. Though they also might be placed otherwise, *i. e.* The greater Degree in these may change its place, as the *Hemitone*, (the less Degree) doth in the *Diatonic Genus*. And from this change chiefly arose the several Moods, *Dorian*, *Lydian*, &c. From all which, their Music no doubt (though it be hard to us to conceive) must afford extraordinary delight and pleasure;

if it did bear but a reasonable Proportion to their infinite Curiosity and Labour. And as we may suppose it to have differed very much from that which now is, and for several Ages hath been used: So consequently we may look upon it as in a manner lost to us.

In prosecution of my Design I am only, or chiefly to insist on the other Kind of Degrees; which are most proper to the Natural Explanation of Harmony; viz. the Degrees *Diatonic*; which are so called; not because they are all *Tones*; but because most of them, as many as can be, are such; viz. in every *Diapason*, 5 *Tones*, and two *Hemitones*. Upon these I say I am to insist, as being, of those before mentioned, the most Natural and Rational.

Digression.

But before we proceed, it may perhaps be a satisfaction to the Reader, after what has been said, to have a little better Prospect of the Ancient Greek Music, by some general Account; not of their whole Doctrine, but of that which relates to our present Subject, *viz.* their Degrees, and Scales of Harmony, and Notes.

First then, take out of *Euclid* the Degrees according to the three *Genera*; which were, *Enharmonic*, *Chromatic*, and *Diatonic*; which Kinds have six Colours (as they call'd them.) *Euclid*, *Introd. Harm.* Pag. 10.

The *Enharmonic* Kind had but one Colour; which made up its *Tetrachord* by these Intervals; a *Diesis* (or Quarter of a Tone,) then such another *Diesis*; and also a *Ditone* incomposit.

The *Chromatic* had three Colours; by which it was divided into *Molle*, *Sesquiplum*, and *Toniaum*.
1st. *Molle*,

1st. *Molle*, in which the Tetrachord rose by a Triental *Diesis* (four of those 12 parts mentioned before) or third part of a *Tone*; and another such *Diesis*; and an Incomposit Interval, containing a *Tone*, and half, and third part of a *Tone*: and it was called *Molle*, because it hath the least, and consequently most Enervated *Spiss* Intervals within the *Chromatic Genus*.

2^d. *Sescuplum*; by a *Diesis* which is *Sesquialtera* to the *Enharmonic Diesis*, and another such *Diesis*, and an Incomposit Interval of 7 *Dieses* Quadrantal; viz. Each being 3 Duodecimals of a *Tone*.

3^d. *Toniaum*; by a *Hemitone*, and *Hemitone*, and *Trihemitone*; and is called *Toniaum*, because the two *Spiss* Intervals make a *Tone*. And this is the ordinary *Chromatic*.

The *Diatonick* had 2 Colours; it was *Molle*, and *Syntonium*.

1st. *Molle*;

1st. *Molle*; by a *Hemitone*, and an incompofit Interval of 3 Quadrantal *Diefes*, and an Interval of 5 fuch *Diefes*.

2^d. *Syntonium*, by a *Hemitone*, and a *Tone*, and a *Tone*. And this is the common *Diatonic*.

To underftand this better, I muft re-affume fomewhat which I mention- ed, but not fully enough before. A *Tone* is fupposed to be divided into 12 leaft parts, and therefore a *Hemitone* contains 6 of thofe Duodecimal (or Twelfth) parts of a *Tone*; a *Diefis Trientalis* 4; *Diefis Quadrantal* 3; The whole *Diateffaron* 30. And the *Diateffaron* in each of the 3 Kinds, was made and perform'd upon 4 Chords, having 3 mean Intervals of Degrees, according to the following Numbers and Proportions of thofe 30 Duodeci- mal parts.

En-

<i>Enharmonic,</i>		by 3, and 3, and 24.
<i>Chromatic,</i>	<i>Molle,</i>	by 4, and 4, and 22.
	<i>Hemiolon,</i>	
	or	by $4\frac{1}{2}$, and $4\frac{1}{2}$, and 21.
	<i>Sescuplum,</i>	
	<i>Toniæum.</i>	by 6, and 6, and 18.
<i>Diatonic,</i>	<i>Molle,</i>	by 6, and 9, and 15.
	<i>Syntonum,</i>	by 6, and 12, and 12.

To each of these Kinds, and the Moods of them, they fitted a perfect Systeme, or Scale of Degrees to *Disdiapason*; as in the following Example taken out of *Nichomachus*: To which I have prefixed our Modern Letters.

E. Nichomacho ; Pag. 22.

A		<i>Nete Hyperbolæon.</i>	
G		<i>Paranete Hyper-</i>	} <i>Enh. Chro. Diat.</i>
		<i>bolæon.</i>	
F		<i>Trite Hyperbolæon.</i>	<i>Enh. Chro. Diat.</i>
E		<i>Nete Diezeugme-</i>	
		<i>non.</i>	
D		<i>Paranete Diezeug-</i>	} <i>Enh. Chro. Diat.</i>
		<i>menon.</i>	
			C <i>Tri-</i>

C	Trite Diezeugme- non.	} Enh. Chro. Diat.
B	Parameſe.	
D	Nete Synemmenon.	
C	Paranete Synem- menon.	} Enh. Chro. Diat.
B	Trite Synemmenon.	
A	Mefe.	
G	Lichanos Meſon.	Enh. Chro. Diat.
F	Parypate Meſon.	Enh. Chro. Diat.
E	Hypate Meſon.	
D	Lichanos Hypaton.	Enh. Chro. Diat.
C	Parypate Hypaton.	Enh. Chro. Diat.
B	Hypate Hypaton.	
A	Proſlambanomenos.	

In this Scale of *Diſdiapaſon*, you ſee the *Mefe* is an *Octave* below the *Nete Hyperboleon*, and an *Octave* above the *Proſlambanomenos*: And the *Lichanos*, *Parypate*, *Paranete*, and *Trite*, are changeable; as upon our Inſtruments are the *Seconds*, and *Thirde*, and *Sixths*,
and

and Sevenths : The *Proslambanomenos*, *Hypate*, *Mese*, *Paramese*, and *Nete*, are Immutable ; as are the Unison, Fourths, Fifths, and Octaves.

Now from the several changes of these Mutable Chords, chiefly arise the several Moods (some call'd them *Tones*) of Music, of which *Euclid* sets down Thirteen ; to which were joyned two more, *viz.* *Hyperæolian* and *Hyperlydian* ; and afterwards Six more were added.

I shall give you for a Taste *Euclid's* Thirteen Moods. *Euclid.* Pag. 19.

Hypermixolydus, five *Hyperphrygius*.
Mixolydus acutior, five *Hyperiaustus*.
Mixolydus gravior, five *Hyperdorius*.

Lydius acutior.

Lydius gravior, five *Æolius*.

Phrygius acutior.

Phrygius gravior, five *Iastius*.

Dorius.

Hypolydus acutior.

Hypo-

Hypolydius gravior, five *Hypoæolius*.

Hypophrygius acutior.

Hypophrygius gravior, five *Hypoiaſtius*.

Hypodorius.

Of theſe the moſt Grave, or Loweſt, was the *Hypodorian* Mood; the *Proſlambanomenos* whereof was fixed upon the loweſt clear and firm Note, of the Voice or Inſtrument that was to expreſs it; And then all along from *Grave* to *Acute* the Moods took their Aſcent by *Hemitones*, each Mood being a *Hemitone* higher or more acute than the next under it. So that the *Proſlambanomenos* of the *Hypermixolydian* Mood, was juſt an Eighth higher than that of the *Hypodorian*, and the reſt accordingly.

Now each particular Chord in the preceding Scale had two Signs or Notes [*σημεῖα*] by which it was characterized or deſcribed in every one of theſe Moods reſpectively, and alſo for
all

all the Moods in the several Kinds of Music ; *Enharmonic*, *Chromatic*, and *Diatonic* ; of which two Notes, the upper was for reading [λείζις] the lower for percussion [κρησις] One for the Voice, the other for the Hand. Consider then how many Notes they used ; 18 Chords severally for 13 Moods (or rather 15, taking in the *Hyperæolian*, and *Hyperlydian*, which are all described by *Alypius*) and these suited to the three Kinds of Music. So many Notes, and so appropriated, had the Scholar then to learn and conn, who studied Music. Of these I will give you in part a View out of *Alypius*.

Notes of the *Lydian Mood* in the
Diatonic Genus.

Ζ. Γ. Π. Φ. C. Ρ. Μ. Ι. Θ.

Η. Γ. Λ. Φ. C. Ο. Π. < . V.

1 2 3 4 5 6 7 8 9

Γ. Υ. Ζ. Ε. Υ. Θ. Λ. Μ. Ι.

Ν. Ζ. C. Υ. Ζ. η. ϰ. Π' < .

10 11 12 13 14 15 16 17 18

- | | | |
|---|--------------------------|--|
| 1 | <i>Proslambanomenos.</i> | { Zeta imperfect, and
Tau jacent. |
| 2 | <i>Hypate Hypaton.</i> | { Gamma averted, and
Gamma right. |
| 3 | <i>Parypate Hypaton.</i> | { Beta imperfect, and
Gamma inverted. |
| 4 | <i>Hypaton Diatonos.</i> | Phi, and Digamma. |
| 5 | <i>Hypate Meson.</i> | Sigma, and Sigma. |
| 6 | <i>Parypate Meson.</i> | Rho, and Sigma inverted |
| 7 | <i>Meson Diatonos.</i> | My, and Pi drawn out |
| 8 | <i>Mese.</i> | Iota, and Lambda jacent. |

L

9 *Trite*

- 9 *Trite Synemmenon*. { *Theta*, and *Lambda* inverted.
- 10 *Synemmenon Diatonos*. { *Gamma*, and *Ny*.
- 11 *Nete Synemmenon*. { Ω Squared, lying Supine upwards; and *Zeta*.
- 12 *Parameſe*. { *Zeta*, and *Pi* jacent.
- 13 *Trite Diezeugmenon*. { Σ Squared, and *Pi* inverted.
- 14 *Diezeugmenon Diatonos*. { Ω Squared, Supine, and *Zeta*.
- 15 *Nete Diezeugmenon*. { *Pbi* jacent, and a careless *Eta* (*n*) drawn out.
- 16 *Trite Hyperbolæon*. { Υ looking downwards, and *Alpha*, left half, looking upwards.
- 17 *Hyperbolæon Diatonos*. { *My*, and *Pi* lengthened, with an Acute above.
- 18 *Nete Hyperbolæon*. { *Iota*, and *Lambda* jacent, with an Acute above.

The Numeral Figures I have added under the Signs (or Marks) only for Reference to the Names of the Notes signified by them, to ſave deſcribing them twice.

Notes of the *Æolian* Mood in the
Diatonic Genus.

Η. ∇. Τ. Χ. Τ. C. Ο. Κ. Ι.

Ε. Η. Γ. ϑ. Ϝ. C. Κ. λ. <

1 2 3 4 5 6 7 8 9

Ζ . Α. Η. Ζ. Α. Χ. Θ. Ο. Κ

Ϛ . \. > . Ϛ . \. Ϝ . η . Κ' λ'

10 11 12 13 14 15 16 17 18

1 *Proslambanomenos.* { *Eta* (H) imperfect a-
verted, and E Qua-
drate averted.

2 *Hypate Hypaton, &c.* { *Delta* inverted, and
Tau jacent, averted,
&c.

Aristides (Pag. 91.) enumerates and describes all the Variations of every Letter in the Greek Alphabet; by which the Signs or Notes above mentioned,

and those of the other Moods, were contrived out of them. They are in all 91 ; including the Proper Letters ; I shall not describe, but only number them.

Out of

A were made	7	N were made	2
B	2	Ξ	2
Γ	7	Ο	2
Δ	4	Π	7
Ε	3	Ρ	2
Ζ	2	Σ	6
Η	5	Τ	4
Θ	2	Υ	3
Ι	4	Φ	4
Κ	3	Χ	4
Λ	5	Ψ	2
Μ	5	Ω	4
	49		42
91			

I shall only add a word or two concerning their Antient use of the Words *Diaſtem* and *System*. *Diaſtem* ſignifies an Interval or Space ; *System* a Con-
junction

junction or Composition of Intervals. So that generally speaking, an *Octave*, or any other *System*, might be truly called a *Diastem*, and very frequently used to be so called, where there was no occasion of Distinction. Though a *Tone*, or *Hemitone*, could not be called a *System*: For when they spoke strictly, by a *Diastem* they understood only an Incomposit Degree, whether *Diesis*, *Hemitone*, *Tone*, *Sesquitone*, or *Ditone*; for the two last were sometimes but Degrees, one *Enharmonic*, the other *Chromatic*. By *System* they meant, a Comprehensive Interval, compounded of Degrees, or of less *Systems*, or of both. Thus a *Tone* was a *Diastem*, and *Diatessaron* was a *System*, compounded of Degrees, or of a 3d. and a Degree. *Diapason* was a *System*, compounded of the lesser *Systems*, 4th, and 5th; or 3d. and 6th; or of a Scale of Degrees: and the Scale of Notes which they used, was their Greatest, or Perfect *System*. Thus with

them, a 3d. *Major*, and a 3d. *Minor*, in the *Diatonic Genus*, were (properly speaking) *Systems*; the former being compounded of two *Tones*, and the latter of three *Hemitones*, or a *Tone* and *Hemitone*: But in the *Enharmonic Kind*, a *Ditone* was not a *System*, but an *Incompofit Degree*; which, added to two *Dieses*, made up the *Diateffaron*: And in the *Chromatic Kind*, a *Trihemitone* was the like; being only an *Incompofit Diastem*, and not a *System*.

But to return from this Digression (which is not so much to my purpose, as to gratify the Reader's Curiosity) and continue our Discourse according to Nature's Guidance, upon the *Diatonic Degrees*. It was said that there are 5 *Tones* and 2 *Hemitones* in every *Diapason*. Now the reason why there must be 2 *Hemitones*, is, because an Eighth is Naturally composed of, and divided into 5th. and 4th; and a Fifth is 3 *Tones* and a half; a Fourth 2 *Tones* and a half;
and

and the Ascent, by Degrees, must pass by Fourth and Fifth ; which are always unchangeable, and keep the same Distance from *Unison* ; and a just *Tone Major* of 9 to 8 always between them. Therefore the *Diapason* has not an Ascent of 6 *Tones* ; but of 5 *Tones* and 2 *Hemitones*, One *Hemitone* being placed in each Fourth Disjunct ; in either of which Fourths, the Degrees may be altered by placing the *Hemitone* in the First, or Second, or Third Degree of either. As, *MI, FA, Sol, La. La, MI, FA, Sol. Sol, La, MI, FA* If this be done in the former *Tetrachord*, then is changed the Second, or Third *Chord* ; If in the other Disjunct *Tetrachord*, then the Sixth, or Seventh is changed : The Fourth and Fifth being Stable and Immutable. By them we Naturally divide the *Diapason* : The Second, Third, Sixth, and Seventh, are alterable, as *Minor*, and *Major*, according to the place of the *Hemitone*.

These *Tones* and *Hemitones* thus placed, are the Degree or Notes, by which an Ascent or Descent is made from the *Unison* to the *Octave*, or through any other *System*; giving all the *Concords* their just Measures or Rations; and without which, we could neither Measure, nor Divide, nor well Practise to learn the greater Intervals, or Systems.

As we Naturally by the Judgment of our Ear, own, and rest in the *Octave*, as the chief Consonant; so we do as Naturally (without Study or Skill in Music) measure the *System* of a *Diapason* by these *Diatonic* Degrees; and can do no otherwise. We cannot with our Voice, without infinite Study, frame to run up or down 8 Notes, without such a Mixture of *Tones* and *Hemitones*; and we do it easiest, when we avoid *Tritones*. We see it in a Ring of Bells, of which the compleatest and most pleasant is a Peal of Six; which are best sorted to have the *Hemitone* in the midst;

i. e. between the Third and Fourth, both in Ascending and Descending; and then there will be no *Tritone*: Ex. gr. *La, Sol, Fa, Mi, Re, Ut.* Where all Ascents and Descents are made by just *Diateffarons*. *Ut, Re, Mi, Fa. Re, Mi, Fa, Sol. Mi, Fa, Sol, La.* Or downwards; *La, Sol, Fa, Mi. Sol, Fa, Mi, Re. Fa, Mi, Re, Ut.*

And this is so Natural that it pleaseth all Ears; and if they should be disposed in any other Order, it would be so disagreeable, that any Rustick or unlearned Ear, of such as know not what a *Tritone* is, would be able to judge, and find a dislike of it. But then, how much more, if the Ring of Bells were disposed by *Chromatic*, or *Enharmonic* Degrees, constituting the *Diateffarons*? how absurd and uncouth it would appear! The practise of those kinds therefore, and in such a manner, seems to be (as has been said) a Violence upon Nature, and only for Curiosity.

In

In *Diatonic Music*, there is but one Sort of *Hemitone* amongst the Degrees, called *Hemitone Major*; whose Ration is 16 to 15: being the Difference, and making a Degree between a *Tone Major*, and *Third Minor*; or between a *Third Major*, and a *Fourth*.

There are two Sorts of *Tones*; viz. *Major*, and *Minor*. *Tone Major* (9 to 8) being the Difference between a *Fourth* and *Fifth*: And *Tone Minor* (10 to 9) which is the Difference between *Third Minor* and *Fourth*. But both the *Tones* arising (as hath been said) out of the Partion of a *Third Major*, in like manner as 5th. and 4th. do by the Partition of an Eighth: I may (with submission) make the following Remark; wherein, if I be too bold, or be mistaken, I shall beg the Reader's pardon.

The Ancient Greek Masters found out the *Tone* by the Difference of a *Fourth* and *Fifth*, subtracting one from the other. But had they found it also
(and

(and that more Naturally) by the Division of a Fifth; first into a *Ditone* and *Sesquitone*, and then by the like proper Division of a true *Ditone* (or Third Major) into its proper parts; they must have found both *Tone Major*, and *Tone Minor*. *Euclid* rests satisfied, That, *Inter super-particulare non cadit Medium*. A super-particular Ratio cannot have a Mediety; viz. in whole Number: which is true in its Radical Numbers. But had he doubled the Radical Terms of a Super-particular, he might have found Mediums most Naturally and Uniformly dividing the Systems of Harmony. *Ex. gr.* The Duple Ratio 2 to 1, as the Excess is but by an Unity; has the Nature of Super-particular: but 2 to 1, the Terms being dupled, is 4 to 2; where 3 is a Medium, which divides it into 4 to 3 (4th.) and 3 to 2 (5th.) Again, 3 to 2, dupling each Term, is 6 to 4; and in the same Manner gives the 2 Thirds, viz. 6 to 3, (3d. Minor) and

and 5 to 4, (3d. *Major*.) Likewise the 3d. *Major*, 5 to 4, dupled as before, 10 to 8, give the 2 *Tones*; i. e. 10 to 9, *Tone Minor*, and 9 to 8, *Tone Major*.

And it seems to be a reason why the Antients. did not discover and use the *Tone Minor*, and consequently not own the *Ditone* for a Concord; because They did not pursue this way of dividing the *Systems*. Although *Euclid* had a fair Hint to search further, when he measured the *Diapason* by 6 *Tones* [*Major*] and found them to exceed the Interval of *Diapason*.

The *Pythagoreans*, not using *Tone Minor*, but two Equal *Tones Major*, in a Fourth, were forced to take a lesser Interval for the *Hemitone*; which is called their *Limma*, or *Pythagorean Hemitone*; and, which added to those two *Tones*, makes up the Fourth: it is a *Comma* less than *Hemitone Major*, (16 to 15;) and the Ration of it, is 256 to 243.

Yet

Yet we find the later Greek Masters, *Ptolemy*, to take Notice of *Tone Minor*; and *Aristides Quintilianus*, to divide a *Sesquioctave Tone* (9 to 8) by dupling the Terms of the Ratio thereof, into 2 *Hemitones*; 18 to 17, and 17 to 16. And those again, by the same way, each into two *Dieses*; 36 to 35, 35 to 34; the Division of 18 to 17, the less *Hemitone*: And 34 to 33, and 33 to 32; the parts of 17 to 16, the greater *Hemitone*. But yet, none of these were the Complement of two *Sesquioctave Tones* to *Diateffaron*: but another *Hemitone*, whose Ratio is about 20 to 19; not exactly, but so near it, that the Difference is only 1216 to 1215; both which together make the *Limma Pythagoricum*.

But I no where find, that they thus divided the 5th, and 3d. *Major*, but rather seemed to dislike this way, because of the Inequality of the *Hemitones* and *Dieses* thus found out; and chose rather
to

to Constitute their Degrees by the *Sesquioctave* Tone, and those Duodecimal supposed Equal Divisions of it. But to return.

There are, you see, 3 Degrees *Diatonic*; viz. *Hemitone Major*, *Tone Minor*, and *Tone Major*. The First of these, some call *Degree Minor*; the Second, *Degree Major*; and the Third, *Degree Maxim*. Now these three Sorts of Degrees are properly to be intermixed, and ordered, in every Ascent to an Eighth, in relation to the Key, or Unison given, and to the Affections of that Key, as to Flat, and Sharp, in our Scale of Music; so, that the Concords may be all true, and stand in their own settled Ration. Wherefore if you change the Key, they must be changed too; which is the Reason why a Harpsichord, whose Degrees are fixed; or a fretted Instrument, the fretts remaining fixt, cannot at once be set in Tune for all Keys: For, if you change the Key, you
withall

withall change the place of *Tone Minor*, and *Tone Major*, and fall into other *Hemitones* that are not proper *Diatonic Degrees*, and consequently into false *Intervals*.

You may fully see this, if you draw Scales of Ascent fitted to several Keys (as are here inserted) and compare them. For an Example of this, Take the First Scale of Ascent to *Diapason* (I) viz. upon C Key Proper, by *Diatonic Degrees*; (making the first to be *Tone Minor*, as convenient for this Instance) intermixing the *Chromatic* and other *Hemitones*, as they are usually placed in the Keys of an Organ; i. e. run up an Eighth upon an Organ (tuned as well as you can) by half Notes, beginning at C *Sol fa ut*, and you will find these Measures. The Proper Degrees standing right, as they ought to be, being described by *Breves*; the other by *Semibreves*: The *Breves* representing the *Tones* of the broad Gradual Keys of an Organ; the *Semibreves* re-
presenting

presenting the Narrow Upper Keys, which are usually called *Musics*. And let this be the first Scale, and a Standard to the rest.

Then draw a Second Scale (II) running up an Eighth in like manner; but let the Key, or First Note, be D. *Sol re* Proper, on the same Organ standing tuned as before; which Key is set a Note (or *Tone Minor*) higher than the former.

Draw also a Third Scale (III) for D *Sol re* Key with Sharps, viz. Third, and Seventh, *Major*; i. e. F, and C, Sharp.

In the First of these Scales, the Degrees (expressed by *Breves*) are set in good and natural Order.

In the Second Scale (changing the Key from C to D) you will find the Fourth, and Sixth, a *Comma* (31 to 80) too much; but between the Fourth, and Fifth, a *Tone Minor*, which should be always a *Tone Major*. So from the Fourth

to

to the Eighth, is a *Comma* short of *Diatente* ; and from the Sixth, a *Comma* short of 3d. *Minor*. And this, because in this Scale, the Degrees are misplaced.

The Third Scale makes the Second; Third, Fourth, and Sixth, from the *Unison*, each a *Comma* too much ; and from the *Octave*, as much too little. In it, the 3d. Degree, between F and G , is not the Proper *Hemitone*, but the Greatest *Hemitone*, 27 to 25. And all this, because in this Scale also, the Degrees are misplaced ; and there happen (as you may see) three *Tones Minor*, and but two *Major* : the Deficient *Comma* being added to the *Hemitone*.

I have added one Example more, of a Fourth Scale ; (IV) viz. beginning at the Key C ; with the like Order of Degrees, as in the First Scale (from the Note C) upon the same Instrument, as it stands tuned after the First Scale. And this will raise the First Scale half a Note higher.

In this Scale, all the *Hemitones* are of the same Measure with those of the First Scale respectively.

And the Intervals should be the same with those of the First Scale ; which has Third, Sixth, Seventh, *Major*.

But in this Fourth Scale, the 1st. Degree, from C to $\flat$ E, is *Tone Major*, and *Diesis* ; as being compounded of 16 to 15, and 27 to 25.

The 2d. Degree from $\flat$ E to F, is *Tone Minor* ; therefore the *Ditone*, made by these two Degrees, is too much by a *Diesis*, (128 to 125) and as much too little the *Trihemitone*, from the *Ditone* to the Fifth.

The 3d. Degree, from F to F , is a *Minor Hemitone*, 25 to 24 ; which, (though a wrong Degree) sets the *Diastessaron* right.

The 4th. Degree, from F to G , is *Tone Major*, and makes a true Fifth.

The 5th. Degree, from G to $\flat$ B, is *Tone Major*, and *Diesis* ; setting the *Hexachord*

chord (or *Sixth*) a *Diesis* and *Comma* too much, or too High. It ought to have been *Tone Minor*.

The 6th. from $\flat B$ to C , is *Tone Minor* ; too little in that place by a *Comma*.

The 7th. from C to $\sharp C$, is *Hemitone Minor* ; too little by a *Diesis*. And so, these two last Degrees are deficient by a *Diesis* and *Comma* ; which *Diesis* and *Comma*, being Redundant (as before) in the 5th. Degree, are balanced by the Deficiency of a *Comma* in the 6th. Degree ; and of a *Diesis* in the 7th : And so the *Octave* is set right.

These Disagreements may be better viewed, if we set together, and compare the Degrees of this IV Scale, and those of the I : where we shall find, no one of all the 7 Degrees, to be the same in both Scales.

Degrees.	Scale I.	Scale IV.
1 st .	<i>Tone Minor.</i>	<i>Tone Maj.& Diesis.</i>
2 ^d .	<i>Tone Major.</i>	<i>Tone Minor.</i>
3 ^d .	<i>Hemit. Major.</i>	<i>Hemitone Minor.</i>
4 th .	<i>Tone Major.</i>	<i>Tone Minor.</i>
5 th .	<i>Tone Major.</i>	<i>Tone Maj.& Diesis.</i>
6 th .	<i>Tone Major.</i>	<i>Tone Minor.</i>
7 th .	<i>Hemit. Major.</i>	<i>Hemitone Minor.</i>

And thus it will succeed in all Instruments, Tuned in order by *Hemitones*, which are fixed upon Strings ; as Harp, &c. Or Strings with Keys ; as Organ, Harpsichord, &c. Or distinguished by Fretts ; as Lute, Viol, &c. For which there is no Remedy, but by some alterations of the Tune of the Strings, in the Two former ; and of the Space of the Fretts in the latter ; as your present Key will require, when you change from one Key to another, in performing Musical Compositions.

Though

Though the Voice, in Singing, being Free, is naturally Guided to avoid and correct those before described *Anomalies*, and to move in the true and proper Intervals: It being much easier with the Voice to hit upon the Right, than upon the *Anomalous* or Wrong Spaces.

Much more of this Nature may be found, if you make and compare more Scales from other Keys. You will still find, that, by changing the Key, you do withall change and displace the Degrees, and make use of Improper Degrees, and produce Incongruous Intervals.

For instead of the Proper *Hemitone*, some of the Degrees will be made of other sort of *Hemitones*; amongst which chiefly are these two: viz. *Hemitone Maxim.* 27 to 25; and *Hemitone Minor*, or *Chromatic*, 25 to 24. Which *Hemitones* constitute and divide the two Tones; viz. *Tone Major*, 9 to 8: the

M 3

Terms

Terms whereof Tripled, are 27 to 24 ; and give 27 to 25, and 25 to 24. The *Tone Minor* likewise is divided into two *Hemitones* : viz. *Major*, 16 to 15 ; and *Minor*, 25 to 24.

These two serve to measure the *Tones*, and are used also, when you Divert into the *Chromatic* kind. But the *Hemitone-Degree* in the *Diatonic Genus*, ought always to be *Hemitone Major*, 16 to 15 ; as being the Proper Degree and Difference between *Tone Major* and *Trihemitone*, between *Ditone* and a Fourth, between Fifth and Sixth *Minor*, between Sixth *Major* and Seventh *Minor*, and also between Seventh *Major* and *Octave*.

Musick would have seem'd much Easier, if the Progression of Dividing had reached the *Hemitones* : I mean, If, as by Dupling the Terms of *Diapason*, 4 to 2 ; it Divides in 4 to 3, and 3 to 2 ; *Diatessaron*, and *Diapente* : And the Terms of *Diapente* dupled, 6 to 4 ; fall into 6 to 5, and

and 5 to 4, *Third Minor*, and *Third Major*; And *Ditone*, or *Third Major*, so Dupled, 10 to 8, falls into 10 to 9, and 9 to 8, *Tone Minor*, and *Tone Major*: If, I say, in like manner, the dupled Terms of *Tone Major* 18 to 16, thus divided, had given Usefull and Proper *Hemitones* 18 to 17, and 17 to 16. But there are no such *Hemitones* found in Harmony, and we are put to seek the *Hemitones* out of the Differences of Other Intervals; as we shall have more Occasion to see, when I come to treat of Differences, in *Chap. 8*.

I may conclude this Chapter, by shewing, how All Consonants, and other Concinnous Intervals, are Compounded of these three Degrees: *Tone Major*, *Tone Minor*, and *Hemitone Major*; being severally placed, as the Key shall require.

Tone Major, and } joyn'd, }
Hemitone Major, } make } 3d. *Minor.*

Tone Major, and } joyn'd, }
Tone Minor, } make } 3d. *Major.*

Tone Major, and } joyn'd, }
Tone Minor, and } make } 4th.
Hemitone Major, }

2 *Tones Major,* } joyn'd, }
 1 *Tone Minor,* } make } 5th.
 1 *Hemitone Maj.* }

2 *Tones Major,* } joyn'd, }
 1 *Tone Minor,* } make } 6th. *Minor.*
 2 *Hemitones Maj.* }

2 *Tones Major,* } joyn'd, }
 2 *Tones Minor,* } make } 6th. *Major.*
 1 *Hemitone Maj.* }

3 *Tones Major,* } joyn'd, }
 1 *Tone Minor, &* } make } 7th. *Minor.*
 2 *Hemitones Maj.* }

3 *Tones Major,* } joyn'd, }
 2 *Tones Minor,* } make } 7th. *Major.*
 1 *Hemitone Maj.* }

3 *Tones*

- | | | | |
|---|----------------------|--|----------------------|
| 3 | <i>Tones Major,</i> | $\left. \begin{array}{l} \text{joyn'd,} \\ \text{make} \end{array} \right\}$ | <i>Diapason.</i> |
| 2 | <i>Tones Minor,</i> | | |
| 2 | <i>Hemit. Major,</i> | | |
| 2 | <i>Tones Major,</i> | $\left. \begin{array}{l} \text{joyn'd,} \\ \text{make} \end{array} \right\}$ | <i>Tritone, or</i> |
| 1 | <i>Tone Minor,</i> | | |
| 1 | <i>Tone Major,</i> | $\left. \begin{array}{l} \text{joyn'd,} \\ \text{make} \end{array} \right\}$ | <i>Semidiapente,</i> |
| 1 | <i>Tone Minor,</i> | | |
| 2 | <i>Hemit. Major,</i> | | |
-

C H A P. VII.

Of Discords.

BESIDES the Degrees, which, though they constitute and compound all Concords, yet are reckoned amongst Discords; because every Degree is Discord to each Chord, to, or from which it is a Degree, either Ascending, or Descending, as being a Second to it: Besides these I say, there are other Discords, some greater and some less. The less will be found amongst the Differences in the next Chapter; and are fit, rather to be known as Differences, than to be used as Intervals.

The greater Discords are generally made of such Concords, as, by reason of misplaced Degrees, happen to have a *Comma*, or *Diesis*, or sometimes a *Hemitone*

mitone too much, or too little : And so become Discords, most of them being of little use ; only to know them, for the better Measuring, and Rectifying the *Systems*. Yet they are found amongst the Scales of our Music.

Sometimes a *Tone Major* being where a *Tone Minor* should have been placed, or a *Tone Minor* instead of a *Tone Major* ; sometime other *Hemitones*, getting the place of the *Diatonic Hemitone Major*, and serving for a Degree, create unapt Discording Intervals : amongst which may be found at least two more Seconds, two more Thirds, two more Sixths, and two more Sevenths. In each of which, one is less, and the other greater, than the true Legitimate Intervals, or Spaces of those Denominations ; as will be more explained in the ensuing Discourse.

But besides these (or rather amongst them, for I here treat of Degrees as Discords) there are two Discords eminently

nently considerable, viz. *Tritone*, and *Semidiapente*. The *Tritone*, (or False Fourth) whose Ration is 45 to 32, consists of 3 whole Notes; viz. 2 *Tones Major*, and 1 *Minor*. The *Semidiapente*, (or False Fifth) 64 to 45; is compounded of a Fourth, and *Hemitone Major*.

And these two divide *Diapason*, 64 to 32, by the Mediety of 45; And they divide it so near to Equality, that in Practice, they are hardly to be distinguished, and may almost pass for one and the same: but in Nature, they are sufficiently distinguished, as may be seen, both by their several Rations, and several Compounding parts.

I think we may reckon *Sevenths* for Degrees, as well as among the greater *Discording Intervals*; because they are but *Seconds* from the *Octave*, and are as truly *Degrees Descending*, as the *Seconds* are in *Ascent*: though they be great *Intervals* in respect of the *Unison*, and as such may be here regarded. These

These Discords, the *Tritone*, and *Semidiapente* ; as also, the Seconds, and Sevenths, are of very great use in Music, and add a wonderfull Ornament and Pleasure to it, if they be judiciously managed. Without them, Music would be much less gratefull ; like as Meat would be to the Palate without Salt or Sawce. But, the further Consideration of this, and to give Directions when, and how to use them ; is not my Task, but must be left to the Masters of Composition.

Discords then, such as are more apt and usefull, (*Intervalla Concinna*) are these which follow.

2d. Minor ; or, <i>Hemitone Major</i> ,	16 to 15.
2d. Major ; <i>Tone Minor</i> ,	10 to 9.
2d. Greatest ; <i>Tone Major</i> ,	9 to 8.
7th. Minor ; 5th. & 3d. Minor,	9 to 5.
7th. Major ; 5th. & 3d. Major,	15 to 8.
<i>Tritone</i> ; 3d. Maj. & <i>Tone Maj.</i>	45 to 32.
<i>Semidiapente</i> ; 4th. & <i>Hemit. Maj.</i>	64 to 45.

These

These are the Simple Dissonant apt Intervals within *Diapason* ; if you go a further compass, you do but repeat the same Intervals added to *Diapason*, or *Dis-diapason*, or *Tris-diapason*, &c. as, *Ex. gra.* a

- 9th. is *Diapason* with a 2d.
- 10th. *Diapason* with a 3d.
- 11th. { *Diapason* with a 4th. or,
 { *Diapason cum Diatessaron.*
- 12th. { *Diapason* with a 5th. or,
 { *Diapason cum Diapente.*
- 15th. *Dis-diapason.*
- 19th. *Dis-diapason cum Diapente.*
- 22th. *Tris-diapason. &c.*

Here, by the way, the Reader may take a little Diversion, in practising to measure the Rations of some of those Intervals, in the foregoing Catalogue of Discords, by comparing them with
Diapason ;

Diapason; as those of the *Sevenths*, which I select, because they are the most distant *Rations* under *Diapason*: *Viz.* *Seventh Minor*, 9 to 5; and *Seventh Major*, 15 to 8. Now to find what *Degree* or *Interval* lies between these and *Diapason*.

First, 9 to 5 is 10 to 5, wanting 10 to 9 (*Tone Minor*.) Next 15 to 8 is 16 to 8, wanting 16 to 15 (*Hemitone Major*.) So the *Degree* between *Seventh Minor* and *Diapason*, is *Tone Minor*; and between *Seventh Major* and *Diapason*, is *Hemitone Major*.

Then he may exercise himself in a Survey of what *Intervals* are comprized in those several *Sevenths*, and of which they are compounded.

First, 9 to 5 comprizeth 9 to 8, and 8 to 5: Or 9 to 8, 8 to 6, and 6 to 5. Next, 15 to 8 contain 15 to 12, 12 to 10, 10 to 9, and 9 to 8: Or 15 to 12, and 12 to 8; Or 15 to 10, and 10 to 8, &c. I suppose, that the
Reader

Reader, before this, is so perfect in these Rations, that I need not lose time to name the Intervals expressed by the Mean Rations, contained in the foregoing Rations of the Sevenths, which shew of what Intervals the several Sevenths are compounded.

Besides these, (by reason of Degrees wrong placed) there are two more 7ths. [false 7ths] one, less than the true ones; and another greater. The least compounded of two Fourths; whose Ratio is 16 to 9, and wants a *Comma* of 7th. *Minor*, and a *Tone Major* of *Diapason*: The other is the greatest, called *Semidiapason*, whose Ratio is 48 to 25; being a *Diesis* more than 7th. *Major*; and wanting *Hemitone Minor* of *Diapason*.

Now first, 16 to 9, is 16 to 8 (2 to 1) wanting 9 to 8; *i. e.* wanting *Tone Major* of *Diapason*; and contains 16 to 10 (8 to 5) and 10 to 9. Or, 16 to 15, 15 to 12 (5 to 4) 12 to 10 (6 to 5) and.

and 10 to 9. Next, *Semi-diapason* 48 to 25, is 50 to 25, wanting 50 to 48; i.e. 25 to 24 (viz. *Henitone Minor*) of *Diapason*.

And the like happens, as hath been said, to the other Intervals, which admit of *Major* and *Minor*; viz. 2ds, 3ds, and 6ths. The 4th, and 5th, and 8th, ought always to remain immutable; though they may suffer too sometimes, and incline to Discord, if we ascend to them by very wrong Degrees; as you may see in the II Scale in the foregoing Chapter: where the Fourth having 2 Tones Major, is a Comma too much.

All these Intervals may be subject to more Mutations, by more absurd placing of Degrees, or of Differences of Degrees; but it is not worth the Curiosity to search farther into them. The Reader may take pleasure, and sufficiently Exercise himself in comparing and measuring these which are already laid before him.

N

But

But to return from this Digression. There are many unapt Discords, which may arise by continual Progression of the same Concords; *i. e.* by Adding (for Example) a 4th. to a 4th, a 5th. to a 5th, &c. For it is observable, That, onely *Diapason* added (as oft as you please) to *Diapason*, still makes Concord: But any other Concord, added to it self, makes Discord.

You will see the Reason of it, when you have considered well the Anatomy (as I may call it) of the Constitutive parts of *Diapason*; which contains, and is composed of 7 Spaces of Degrees, or of 4th. and 5th, or of 3ds. and 6ths, or of 2ds. and 7ths; which must all keep their true Measures and Rations belonging to them, and otherwise are easily and often disordered.

Then, consider *Diapason* as constituted of two Fourths Disjunct, and a *Tone Major* between them. And this last is most needfull to be very well considered;

dered ; as most plainly shewing the Reasons of those Anomalies, or Irregular Intervals, which are produced by Changing the Key ; and consequently giving a new and wrong place to this *Odd Tone Major*, which stands in the midst of *Diapason*, between the two *Fourths Disjunct*.

Every 4th. must consist of one *Tone Major*, one *Tone Minor*, and one *Hemitone Major*, as its Degrees, placing them in what Order you please ; whose Rations, added together, make the Ration of *Diatessaron*. And of these same Degrees contained in the 4th, are made the two 3ds, which constitute the 5th. *Tone Major* and *Hemitone Major* make the less 3d, or *Tribemitone* ; *Tone Major* and *Tone Minor* make the Greater 3d, or *Ditone* ; *Tribemitone* and *Ditone* make *Diapente* ; *Tribemitone* and *Tone Minor* (as likewise *Ditone* and *Hemitone Major*) make *Diatessaron*.

Now this *Tone Major*, that stands in the middle of *Diapason*, between the two 4ths, which it disjoins; and the Degrees required to the 4ths, will not in a fixed Scale stand right, when you alter your Key, and begin your Scale of *Diapason* from another Note. For that which was the 5th, will now be the 4th, or 6th, &c. And then the Degrees will be disordered, and create some discording Intervals. If you continue conjunct Fourths, there will be a Defect of *Tones Major*; if you continue conjunct Fifths, there will be too many *Tones Major* in the Systems produced. And if a *Tone Major* be found, where it ought to have been a *Tone Minor*; or a *Minor* instead of a *Major*; that Interval will have a *Comma* too much, or too little. And so likewise will from a wrong *Hemitone* be found the Difference of a *Diesis*. And these two, *Comma* and *Diesis*, are so often Redundant, or Deficient, according as the Degrees happen to be disordered or mis-placed; that

that thereby, the Difficulties of fixing half Notes of an Organ in tune for all Keys, or giving the true Tune by Fretts, become so Insuperable.

You see, that in every Space of an Eighth, there are to be 3 *Tones Major*, and 2 *Tones Minor*, and 2 *Hemitones Major*: One *Tone Major* between the *Diatessaron* and *Diapente*, and a *Tone Major*, a *Tone Minor*, and *Hemitone Major* in each of the Disjunct Fourths.

These are the Proper Degrees by which you should always Ascend or Descend through *Diapason*, in the *Diatonic* Kind; which *Diapason*, being the compleat System, containing all primary Simple *Harmonic* Intervals that are; (and for that reason called *Diapason*;) You may multiply it, or add it to its self as oft as you please, as far as Voice or Instrument can reach; and it will still be Concord, and cannot be disordered by such addition: because every of them will contain (however placed) just
3 *Tones*

3 *Tones Major*, 2 *Tones Minor*, and 2 *Hemitones Major*.

Whereas, if you add any other Interval to it self, the Degrees will not fall right, and it will be Discord, because all Concords are compounded of unequal Parts, as hath been shew'n before; and if you carry them in Equal Progression, they will mix with other Intervals by incongruous Degrees, and those Disordered Degrees will create a Dissonant Interval. See the following Scheme of it.

2 3 ds. <i>Minor</i>	} make {	5 th, wanting <i>Hem. Min.</i>
2 3 ds. <i>Major</i>		5 th, and <i>Hemit. Minor</i> .
2 4 ths.		8 th, wanting <i>Tone Maj.</i>
2 5 ths.		8 th, and <i>Tone Major</i> .
2 6 ths. <i>Minor</i>		8 th, and <i>Ditone, & Diesis</i> .
2 6 ths. <i>Major</i>		8 th, & 4 th, & <i>Hem. Min.</i>

To which may be added, That

2 <i>Tones Min.</i>	} make {	<i>Ditone</i> , wanting a <i>Comma</i> .
2 <i>Tones Maj.</i>		<i>Ditone</i> , and a <i>Comma</i> .

It

It was said above, that *Diapason* may be added to it self as oft as you please, and there will be no disorder, because every one of them will still retain the same Degrees of which the first was Composed: But it is not so in other Concords; of which I will add one more Example, because of the use which may be made of it.

Make a Progression of 4 *Diapente's*, and, as was shewed in the 5th. Chapter, (Pag. 102.) it will produce *Dis-diapason*, and 2 *Tones Major*, which is a 17th, with a *Comma* too much. Because in that Space there ought to be just 7 *Tones Major*, and 5 *Tones Minor*; Whereas in 4 *Fifths* continued, there will be found 8 *Tones Major*, and but 4 *Tones Minor*: So that a *Tone Major*, getting the place of a *Tone Minor*, there will be in the whole System a *Comma* too much. One of these *Major Tones* should have been a *Tone Minor*, to make the Excess above *Dis-diapason* a just *Ditone*.

On the other side, if you continue the Ration of 4 *Diateffarons*, there will be a *Tone Minor*, instead of a *Tone Major*; and consequently a *Comma* deficient in constituting *Diapason* and 6th. *Minor*. For since every Fourth must consist of the Degrees of *Tone Minor*, one *Tone Major*, one *Hemitone Major*; it follows that if you continue 4 Fourths, there will be 4 *Tones Minor*, 4 *Tones Major*, and 4 *Hemitones Major*. Whereas in the Interval of *Diapason* with 6th. *Minor*, there ought to be 5 *Tones Major*, and but 3 *Minor*.

By this you may see the Reason, why, to put an Organ or Harpsichord into more general usefull Tune, you must tune by 8ths, and 5ths; making the 8ths. perfect, and the 5ths. a little bearing downward; *i. e.* as much as a quarter of a *Comma*, which the Ear will bear with in a 5th, though not in an 8th. For Example, begin at C *Fa ut*; make C *Sol fa ut* a perfect 8th. to it, and G *Sol*
re ut

Handwritten musical notation on three systems of staves. The notation includes various symbols such as circles, crosses, and letters (e.g., 'b', 'o', 'x') placed on and around the staves. The first system has a treble and bass staff. The second system has a treble and bass staff. The third system has a single staff. The notation is somewhat abstract and appears to be a form of shorthand or a specific musical notation system.

Place this ag^t
Page 181.

re ut a bearing 5th; Then tune a perfect 8th. to G, and a bearing 5th. at D *La sol re*; and from thence downwards (that you may keep towards the middle of the Instrument) a perfect 8th. at D *Sol re*: and from thence a bearing 5th. up at A; and from A, a perfect 8th. upwards, and bearing 5th. at E *La mi*. From E an 8th. downwards; and so go on, as far as you are led by this Method, to tune all the Middle part of the Instrument: and at last fill up all above, and below, by 8ths. from those which are settled in Tune; according to the Scheme annexed. Observing (as was said) to Tune the Eighths perfect, and the Fifths a little bearing Flat; except in the three last Barrs of Fifths, where the Fifths begin to be taken downward from C, as they were upwards in all before: Therefore, as before, the Fifth above bore downward; so here, the Fifth below must bear upward, to make a Bearing Fifth; but
That

That being not so easie to be judged, Alter the Note below, till you judge the Note above to be a Bearing Fifth to it. This will rectifie both those Anomalies of 5ths and 4ths. For the 5th. to the *Unison*, is a 4th. to the *Octave*; and what the 5th. looseth by Abatement, the 4th. will gain: which doth in a good Degree rectifie the Scale of the Instrument. Taking care withall, that what Anomalies will still be found in this *Hemitonic* Scale, may, by the Judgment of your Ear, in Tuning, be thrown upon such Chords as are least used for the Key: as $\times$ G, $\flat$ E, &c. Even which the Ear will bear with, as it doth with other Discords in binding passages; if so, you close not upon them. But the other Discords, so used, are most Elegant; these only more Tolerable.

C H A P. VIII.

Of Differences.

ALL Rations and Proportions of inequality, have a Difference between them, when compared to one another; and consequently the Intervals, expressed by those Rations, differ likewise. A Fifth is Different from a Fourth, by a *Tone Major*; from a 3d. *Minor*, by a 3d. *Major*; so an 8th. from a 5th, by a 4th. Of the Compounding parts of any Interval, one of them is the Difference between the other part and the whole Interval.

But I treat now of such Differences as are generally less than a *Tone*, and create the Difficulties, and Anomalies occurring in the two foregoing Chapters. I have the less to say of them
a-part,

a-part, because I could not avoid touching upon them all along. It will onely therefore be needfull, to set before you an orderly view of them. And first, taking an account of the true *Harmonic* Intervals with their Differences, and the Degrees by which they arise; it will be easier to judge of the false Intervals, and of what concern they are to Harmony.

Table of true *Diatonic* Intervals within *Diapason*, with the Differences between them.

		Their Rations.	Their Differen- ces.
<i>Hemitone Major.</i>		16 to 15	25 to 24
<i>Tone Minor.</i>		10 to 9	81 to 80
<i>Tone Major.</i>		9 to 8	16 to 15
3d. <i>Minor</i> ;	} Compounded of	6 to 5	25 to 24
3d. <i>Major</i> ;		5 to 4	10 to 9
4th.		4 to 3	9 to 8
5th.		3 to 2	16 to 15
6th. <i>Minor</i> ;		8 to 5	25 to 24
6th. <i>Major</i> ;		5 to 3	27 to 25
7th. <i>Minor</i> ;		9 to 5	25 to 24
7th. <i>Major</i> ;		15 to 8	16 to 15
<i>Diapason</i> ;		2 to 1	
<i>Tritone</i> ;		45 to 32	2048 to
<i>Semidiapente</i> ;		64 to 45	2025
	<i>Tone Maj. & Hemit. Maj.</i>		
	<i>Tone Major & Tone Minor.</i>		
	3d. <i>Minor & Tone Min.</i>		
	or 3d. <i>Major & Hemitone Major.</i>		
	4th, and <i>Tone Major</i> ;		
	or of the two 3ds.		
	5th, and <i>Hemit. Major</i> ;		
	or 4th, and 3d. <i>Min.</i>		
	5th, and <i>Tone Minor</i> ;		
	or 4th, and 3d. <i>Major.</i>		
	6th <i>Maj. & Hem. Max.</i>		
	or 6th. <i>Minor & Tone Major</i> ;		
	or 5th, and 3d. <i>Minor.</i>		
	6th. <i>Major, & Tone Maj.</i>		
	or 5th, & 3d. <i>Major.</i>		
	7th, and 2d. or 6th, & 3d. or 5th, & 4th.		
	3d. <i>Major</i> , and <i>Tone Maj.</i>		
	4th, and <i>Hemit. Major.</i>		

Those which arise from the Differences of Consonant Intervals, are called *Intervalla Concinna*, and properly appertain to Harmony: The rest are necessary to be known, for making and understanding the Scales of Musick.

Table

Table of false *Diatonic* Intervals, caused by Improper Degrees; with their Rat-ions and Differences from the true Intervals.

This Mark + stands for *More*; — for *Less*.

			Rat-ions.	Differences from the true.
Tribemi- tone	Least;	Tone Minor, and Hemit. Major.	32 to 27	81 to 80 —
	Greatest;	Tone Major, and Hemit. Max.	243 to 200	81 to 80 +
Ditone	Least;	2 Tones Minor.	100 to 81	81 to 80 —
	Greatest;	2 Tones Major.	81 to 64	81 to 80 +
Fourth	Less;	2 Tones Minor, & Hemit. Major.	320 to 243	81 to 80 —
	Greater;	2 Tones Major, & Hemit. Major.	27 to 20	81 to 80 +
Fifth	Less;	Less 4th, and Tone Major.	40 to 27	81 to 80 —
	Greater;	Greater 4th, & Tone Major.	143 to 160	81 to 80 +
Sixth	Least;	5th, and Hemit. Minor.	25 to 16	81 to 80 —
	Greatest;	5th, and Tone Major.	27 to 16	81 to 80 +
Seventh	Least;	6th. Major, and Hemit. Major.	16 to 9	81 to 80 —
	Greatest;	6th. Minor, and 3d. Minor.	48 to 25	128 to 125 +

Here

Here in this account may be seen, how frequently the *Comma*, and the *Diesis* Abounding, or Deficient, by reason of Mis-placed Degrees, occasion Discord in *Harmonic* Intervals.

The *Comma*, by reason of a wrong *Tone*, *i.e.* too much ; when a *Tone Major* happens where there ought to be a *Tone Minor* : or too little, when the *Tone Minor* is placed instead of the *Major*. And the *Diesis* is Redundant, or Deficient, by reason of a wrong *Hemitone* ; when the *Major* happens instead of the *Minor*, or the Contrary : the *Diesis* being the Difference between them. And if *Hemitonium Maximum* get in the place of *Hemitonium Majus*, the Excess will be a *Comma* ; if in the place of *Hemitone Minor*, the Excess will be *Comma* and *Diesis*.

And these Anomalies are not Imaginary, or only Possible, but are Real in an Instrument fixed in Tune by *Hemitones* ; as, *Organ*, *Harpsichord*, &c. And the Reader may find some of them amongst

mongst those 4 Scales of *Diapason*, in the 6th. Chapter ; to which also more may be added : Out of the First of which, I have Selected some Examples ; using the common Marks, as before : viz. +, for *More* ; and — for *Less*, or *Wanting*..

From	⌘ C, to ♭ E;	{ Tone Major, + Diesis ; or, 3 d. Min. Hemit. Min.
	⌘ C, to F ;	{ 3 d. Major, + Diesis ; or, 4th, — Hemit. Minor.
	D, to G ;	4th, + Comma.
	♭ E, to ⌘ F ;	{ 3 ^d Min.—Dies.& Com.or Tone Min. + Hem. Min.
	♭ E, to ⌘ G ;	{ 4th, — Diesis ; or, 3 d. Maj. + Hem. Min.
	⌘ F, to ♭ B ;	{ 3 d. Maj. + Dies.& Com.or 4th, — Hem. Subminim.
	⌘ F, to B ;	4th, + Comma.
	⌘ G, to ♭ B ;	{ Tone Maj. + Diesis ; or, 3 d. Min. — Hemit. Min.
	⌘ G, to C ;	{ 3 d. Maj. + Diesis ; or, 4th, — Hemit. Min.
	B, to D ;	3 d. Min. — Comma.

Next,

Next, take account of some Differences which constitute several *Hemitones*.

Difference between	{ <i>Tone Major</i> , and <i>Hemit. Minor</i> .		{ <i>Hem. Maxim.</i> 27 to 25
	{ <i>3d. Major</i> , and <i>4th.</i>		{ <i>Hemit. Majus:</i> 16 to 15
	{ <i>Tone Major</i> , and <i>Hemit. Major</i> .		{ <i>Hemitone Medium.</i> } 135 to 128
	{ <i>3d. Minor</i> , and <i>3d. Maj.</i>		{ <i>Hem Min. Di-</i> <i>esis Chromat.</i> } 25 to 24
	{ <i>2 Tones Major</i> , and <i>4th.</i>		{ <i>Hemiton.</i> (or <i>Limma</i>) <i>Pythagor.</i> } 256 to 243
	{ <i>Tone Maj.</i> and <i>Limma.</i>		{ <i>Apotome</i> 2187 to 2048; or <i>Hemit. Med.</i> with <i>Comma.</i>

To which may be added, out of *Mersennus*.

Differ. between	{ <i>Hemit. Maxim.</i> and <i>Hemit Minor.</i>		{ <i>Hemitonium.</i> <i>Minimum.</i> } 648 to 625
	{ <i>Tone Minor</i> , and <i>Hemitone Maxim.</i> or, <i>Hemitone Minor</i> , and <i>Comma.</i>		{ <i>Hemitonium.</i> <i>Subminimum.</i> } 250 to 243

Next, take a farther View of Differences, most of which arise out of the preceding Differences, by which you will

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will better see how all Intervals are Compounded, and Differenced; and more easily judge of their Measures.

Table of more Differences.

Difference between	Tone Maj. and Tone Min.	Comma.
	Tone Maj. and Hem. Greatest.	Hemitone Minor.
	Tone Maj. & Hem. Medium.	Hemitone Major.
	Tone Maj. and Hem. Pythag.	Apotome.
	Hem. Greatest, and Hem. Maj.	Comma.
	Hem. Greatest, & Hem. Min.	{ Comma, and Diesis; viz. Hem. Minimum.
	Hemit. Major, and Minor.	Diesis.
	Hemit. Major, and Medium.	{ 2048 to 2025. viz. Comma Minus.
	Hemit. Major, and Pythag.	Comma.
	Apotome, and Hemit. Majus.	{ Diff. betw. Comma Majus, and Min.
	Apotome, and Hemit. Med.	Comma.
	Apotome, and Hem. Pythag.	{ Comma, and the aforesaid Differ.
	Apotome, and Hemit. Minus.	2 Comma's.
	Hemit. Medium, and Pythag.	{ Differ. of Comma Majus, and Minus.
	Hemit. Medium, and Minus.	Comma.
	Hemit. Pythag. and Minus.	Comma Minus.
	Hemit. Minus, and Diesis.	{ Somewhat } 3125 more than } to Comma, viz. } 3072.
	Hemit. Minus, and Comma.	Hem. Subminimum.
	Diesis, and Comma.	{ Comma Minus, viz. 2048 to 2025.
	Com. Majus, and Com. Minus.	32805 to 32768.

These

These Differences (with some more) are found between several other Intervals ; of which more Tables might be drawn, but I shall not trouble the Reader with them. Having here shewn what they are, he may (if he please) exercise himself to examine These by Numbers, and also find out Them ; and to some it may be pleasant and delightfull ; And for that reason, I have the more largely insisted on this part of my Subject, which concerns the Measures, Habitues, and Differences of Harmonic Intervals.

I shall add one Table more ; of the Parts, of which these lesser Intervals are Compounded ; which will still give more Light to the former ; and is, in Effect, the same.

Tone Major contains, & is compounded of { *Tone Minor*, and *Comma*. { *Hemitone Maxim.* and *Hemitone Min.*
Tone Min. { *Hemitone Maj.* { *Limma*, { 2 *Hem. Min.*
{ *Hemitone Med.* { *Apotome*. { 1 *Diesis*,
{ 1 *Comma*.
Hem. Max. { *Hem. Maj.* { *Hem. Med.* { *Hem. Pyth.* { *Hem. Min.*
{ *Comma*. { *Diesis*. { 2 *Comma's*. { *Diesis* & *Comma*.
Hem. Maj. { *Hem. Med.* { *Hem. Pyth.* { *Hem. Min.* { *Hem. Submi.*
{ *Com. Min.* { *Comma*. { *Diesis*. { *Diesis* & *Comma*.
Hem. Med. { *Hem. Min.* { *Hemitone Pythagoricum*.
{ *Comma*. { Difference between *Comma Majus*,
and *Minus*, viz. 32805 to 32768.
Hem. Pyth. { *Hemitone Minus*.
{ *Comma Minus*.
Hem. Min. { *Hemit. Submin.* { *Diesis*, and
{ *Comma*. { 3125 to 3072.
Diesis. { *Comma*,
{ *Comma Minus*.
Comma. { *Comma Minus*,
{ 32805 to 32768.

I think there scarce needs an Apology for some of these Appellations, in respect of Grammar. That I call *Hemitonium*, and *Hexachordon*, *Majus*, and *Minus* ; sometimes *Hemitone*, and *Hexachord*, *Major*, and *Minor*. These two last Words are so well adapted to our Language, that there is no *English*-man, but knows them. Therefore when I make *Hemitone* an *English* word, I take *Major*, and *Minor*, to be so too ; and fittest to be joyned with it, without respect of *Gender*.

C H A P. IX.

Conclusion.

TO Conclude all. Bodies by Motion make Sound ; Sound, of fitly Constituted bodies, makes Tune : Tune, by Swiftneſs of Motion is rendered more Acute ; by Slowneſs more Grave : in Proportion to the Measure of Courſes and Recourſes, of Tremblings or Vibrations of Sonorous Bodies. Thoſe Proportions are found out by the Quantity and Affections of Sounding Bodies. *Ex. gr.* by the Length of Chords. If the Proportion of Length (*Cæteris paribus,*) and conſequently of Vibrations of ſeveral Chords, be commensurate within the Number 6 ; then thoſe Intervals of Tune are Conſonant, and make Concord, the Motions mix-

ing and uniting as they pass : If incommensurate , they make Discord by the jarring and clashing of the Motions. Concords are within a limited Number, Discords innumerable. But of them, those only here considered, which are (as the *Greeks* termed them) ἐμμελῆ, *Concinnous*, apt and usefull in Harmony : Or which, at least, are necessary to be known, as being the Differences and Measures of the other ; and helping to discover the reason of Anomalies, found in the Degrees of Instruments tuned by *Hemitones*.

All these I have endeavoured to explain, with the manifest Reasons of Consonancy and Dissonancy, (the Properties of a *Pendulum* giving much light to it,) so as to render them easie to be understood by almost all sorts of Readers ; and to that end have enlarged , and repeated, where I might, to the more intelligent Reader, have comprized it very much shorter. But I hope
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the Reader will pardon that, which could not well be avoided, in order to a full, and clear Explanation of that, which was my design, *viz.* the Philosophy of the Natural Grounds of Harmony.

Upon the Whole; You see how Rationally, and Naturally, all the Simple Concords, and the Two *Tones*, are found and demonstrated, by Sub-divisions of *Diapason*.

2 to 1, *i. e.* 4 to 2; into 4 to 3, and 3 to 2.
 2 to 1, *i. e.* 6 to 3; into 6 to 5, and 5 to 3.
 2 to 1, *i. e.* 8 to 4; into 8 to 5, and 5 to 4.
 2 to 1, *i. e.* 10 to 5; into 10 to 9, 9 to 8, and 8 to 5.

In which are the Ratios (in Radical, or Least Numbers) of the *Octave*, Fifth, Fourth, Third *Major*, Third *Minor*, Sixth *Major*, Sixth *Minor*, and *Tone Major*, and *Tone Minor*.

And then, All the *Hemitones*, and *Diesis*, and *Comma*, are found by the Differences of these, and of one another; as hath been shewn at large.

Now, certainly, this is much to be preferred before any Irrational Contrivance of expressing the several Intervals. The *Aristoxenian* way of dividing a *Tone* [*Major*] into 12 Parts, of which 3 made a *Diesis*, 6 made *Hemitone*, 30 made *Diateffaron*; (as hath been said) might be usefull, as being easier for Apprehension of the Intervals belonging to the three Kinds of Musick ; and might serve for a least common Measure of all Intervals, (like Mr. *Mercator's* artificial *Comma*) 72 of them being contained in *Diapason*.

But this way, and some other Methods of dividing Intervals equally, by *Surd Numbers* and *Fractions*, attempted by some Modern Authors ; could never constitute true Intervals upon the Strings of an Instrument, nor afford any Reason for the Causes of Harmony, as is done by the Rational Way, explaining Consonancy by united Motions, and Coincidence of Vibrations. And though they supposed such Divisi-

ons of Intervals; yet we may well believe, that they could not make them, nor apply them in tuning a Musical Instrument; and if they could, the Intervals would not be true nor exact. But yet, the Voice offering at those, might more easily fall into the true Natural Intervals. *Ex. gr.* The Voice could hardly express the Antient *Ditone* of 2 *Tones Major*; but aiming at it, would readily fall into the Rational Consonant *Ditone* of 5 to 4, consisting of *Tone Major*, and *Tone Minor*. It may well be rejected as unreasonable, to measure Intervals by Irrational Numbers, when we can so easily discover and assign their true Rations in Numbers, that are *Minute* enough, and easie to be understood.

I did not intend to meddle with the Artificial part of Musick: The Art of Composing, and the Metric and Rhythmical parts, which give the infinite Variety of Air and Humor, and indeed the very Life to Harmony; and which
can

can make *Musick*, without Intervals of Acuteness and Gravity, even upon a Drum; and by which chiefly the wonderfull Effects of Musick are performed, and the Kinds of Air distinguished; As, *Almand*, *Corant*, *Jigg*, &c. which variously attack the Fancy of the Hearers; some with Sprightfulness, some with Sadness, and others a middle way. Which is also improved by the Differences of those we call Flat, or Sharp Keys; The Sharp, which take the Greater Intervals within *Diapason*, as 3ds, 6ths, and 7ths. *Major*; are more Brisk and Airy; and being assisted with Choice of Measures last spoken of, do Dilate the Spirits, and Rouze them up to Gallantry, and Magnanimity. The Flat, consisting of all the less Intervals, contract and damp the Spirits, and produce Sadness and Melancholy. Lastly, A mixture of these, with a suitable *Rhythmus*, gently fix the Spirits, and compose them in a middle Way: Wherefore the

First

First of these is called by the Greeks *Diaſtaltic*, Dilating; the ſecond, *Syſtaltic*, Contracting; the laſt, *Heſychiaſtic*, Appeaſing.

I have done what I deſigned, ſearch-
ed into the Natural Reaſons and Grounds,
the Materials of Harmony; not pre-
tending to teach the Art and Skill of
Muſick, but to diſcover to the Reader
the Foundations of it, and the Reaſons
of the *Anomolous Phænomena*, which oc-
cur in the Scales of Degrees and Inter-
vals: Which though it be enough to
my Purpoſe, yet is but a ſmall (though
indeed the moſt certain, and, conſe-
quently moſt delightfull) Part of the Phi-
loſophy of Muſick; in which there remain
Infinite Curious Diſquiſitions that may
be made about it: As what it is, that
makes Humane Voices, even of the ſame
Pitch, ſo much to differ one from ano-
ther? (For though the Differences of Hu-
mane Countenances are viſible; yet we
cannot ſee the Differences of Inſtruments
of

of Voice, nor consequently of the Motions and Collisions of Air, by which the Sound is made.) What it is that constitutes the different Sounds of the Sorts of Musical Instruments, and even single Instruments? How the Trumpet, only by the Impulse of Breath, falls into such variety of Notes, and in the Lower Scale makes such Natural Leaps into Consonant Intervals of 3d, 4th, 5th, and 8th. But this I find is very ingeniously explicated by an Honourable Member of the R. S. and published in the *Philosophical Transactions*, N^o 195. Also how the *Tube-Marine*, or Sea-Trumpet (a *Monochord*) so fully expresseth the Trumpet; and is also made to render other Varieties of Sounds; as, of a Violin, and Flageolet, whereof I have been an Ear-witness? How the Sounds of Harmony are received by the Ear; and why some persons do not love Musick? &c.

As to this last; the incomparable Dr. *Willis* mentions a certain Nerve in Brain, which some Persons have , and some have not. But further, it may be considered, that all Nerves are composed of small Fibres ; Of such in the Gutts of of Sheep, Cats, &c. are made Lute-Strings : And of such are all the Nerves, and amongst them, those of the Ear, composed. And, as such, the latter are affected with the Regular Tremblings of Harmonic Sounds. If a false String (such as I have before described) transmit its Sound to the best Ear ; it displeaseth. Now, if there be found falseness in those Fibres, of which Strings are made ; Why not the like in those of the Auditory Nerve in some Persons ? And then it is no wonder if such an Ear be not pleased with Musick, whose Nerves are not fitted to correspond with it, in commensurate Impressions and Motions. I gave an Instance in *Chap. 3d.* how a Bell-Glass will Tremble and Eccho to its own
Tune,

Tune, if you hit upon it: And I may add, That if the Glafs ſhould be irregularly framed, and give an uncertain Tune, it would not answer your Trial. In fine, Bodies muſt be Regularly framed to make Harmonic Sounds, and the Ear Regularly conſtituted to receive them. But, this by the by; and only for a Hint of Inquiry.

I was ſaying, that there remain Infinite Curioſities relating to the Nature of Harmony, which may give the moſt A-
cute Philoſopher buſineſs, more than enough, to find out; and which perhaps will not appear ſo eaſie to demonſtrate and explain, as are the Natural Grounds of Conſonancy and Diſſonancy.

After all therefore, and above all, by what is alraedy diſcovered, and by what yet remains to be found out; we cannot but ſee ſufficient cauſe to Rouze up our beſt Thoughts, to Admire and Adore the Infinite Wiſdom and Goodneſs of Almighty God. His Wiſdom

in ordering the Nature of Harmony in so wonderfull a manner, that it surpasseth our Understanding to make a through Search into it, though, (as I said) we find so much by Searching, as does recompence our Pains with Pleasure, and Admiration.

And his Goodness, in giving Musick for the Refreshings and Rejoycings of Mankind; so that it ought, even as it relates to common Use, to be an Instrument of our great Creator's Praise, as he is the Founder and Donor of it.

But much more, as it is advanced and ordained to relate immediately to his Holy Worship, when we Sing to the Honour and Praise of God. It is so Essential a part of our Homage to the Divine Majesty, that there was never any Religion in the World, *Pagan, Jewish, Christian, or Mehumetan*, that did not mix some kind of Musick with their Devotions; and with Divine Hymns, and Instruments of Musick, set forth the
Honour

Honour of God, and celebrate his Praise. Not only, *Te decet Hymnus Deus in Sion.* (Psal. 65.) but also ----- *Sing unto the Lord all the whole Earth.* (Psal. 96.)

And it is that, which is incessantly performed in Heaven before the Throne of God, by a General Consort of all the Holy Angels and the Blessed.

In short, we are in Duty and Gratitude bound to bless God, for our Delightfull Refreshments by the use of Musick ; But especially in our publick Devotions, we are obliged by our Religion, with Sacred Hymns and Anthems, to magnifie his Holy Name ; that we may at last find Admittance above, to bear a Part in that Blessed Consort, and Eternally Sing *Allelujahs*, and *Trisagions* in Heaven.

Δόξα τῷ Θεῷ.

F I N I S.



